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OWEN JONES, F.R.S., F.S.A.

DECORATION by colour and form is one of the fountains of wealth and beauty, of instruction and elevation, that distinguish our century among the years of English history; and there is no person whose life has been at all similarly fruitful of good results, whether we take those results as tentative or the excitement of hostile controversy, as has been the life of this distinguished man. Indeed, after having in these pages enumerated the qualities, and described the labours of Sir Joseph Paxton, Sir Charles Fox, and Sir Digby Wyatt, it must recur to every reader of art literature, and every observer of the course of art education, and every chronicler of the results of such creations that some notice must be made concerning him who was the ornament of them all; him who excelled them in labour; who in his department not only obtained, but clearly deserved national pre-eminence: who has left for future generations imperishable evidences of the grandeur of idea, the power of art, sympathy with past ages, and the truest conception of what is alike the honour and duty of this and succeeding intelligent communities.

Of versatility most excellent, because in it was nothing frivolous; in design most uniform, because its guiding principle had equal influence, whether in the formation of a bookbinder's pattern for side gilding, or in the distemper work of a nobleman's best room.

Wandering among the most precious relics of long past-by ages, he could select the most precious fragments; and with the skill of a geologist, and with ten times more attractiveness, evolve the ground plan, the elevation, the colouring, and the furniture, from a consciousness that has its vindication from subsequent research, and a vindication from its inherent harmony—and there comes before us a work like the Alhambra Court in the Crystal Palace: a work now destroyed and not to be reproduced: a work that had no equal and no one living can imitate; but a work of marvellous beauty, instruction, and power.

Owen Jones died in 1874: he was born in Wales about the year 1809. Birthdays are not sternly recorded in that venerable land. He came up to London very early, and had the great advantage of having for his instructor a man well known in the West End of London, by repute and tradition, for his fine faculty as an architect and his honour as a negotiator—Mr. Lewis Vuillamy, who held at that time the highest position in London in all matters of architectural decoration. In that gentleman's office, Owen Jones acquired the tastes and also the knowledge

of such available sources as would nourish those tastes whether in England or the Continent; and when his time of probation expired he resolved to take a tour through Europe and try his own fortune. Sacrificing all he had, he started for his four years' travel—a travel destined to distinguish his age by the revival through him of modes of colouring, and principles of art, altogether unknown and, of course, unobserved in England.

Through the whole of his communications to the artistic and general public, the lessons then received are enforced in every form and at every opportunity. He saw wherein we in England were seriously deficient, notwithstanding our national supremacy in power, wealth, and industry; notwithstanding the untiring industry that could by its own magnetic force attract the products of every clime, and make it available for the service of man: that we could utilize nature far beyond any other race: but that as to Art we were altogether in the rear. He determined to do his part in remoulding popular taste: and in that work to adopt the principle, that the study of progressive development in the forms of the past, founded on the eternal principles which all good forms of art supply, must be the absolute source of our inspiration, the indicator of the way we should go, if we would attain a higher perfection.

Colour became Mr. Jones' favourite study, and the incessant vigour, the boldness, the almost audacity of his attack on the existent practice, and his all but idolatry of the masters whose works he had seen in the great travels undertaken with M. J. Goury in Granada, and subsequently with Wyatt in Italy, brought about him an atmosphere of hostility of which we now have but a faint impression. The whole army of architects and decorators flew to arms; but the public welcomed his instructions. The craftsmen hated his advent, but the intelligence of the country recognised the presence of a much-wanted teacher, and a welcome example. When he insisted on the superiority of Eastern over Western Art, the profession derided him, but the public did not. His having the charge of decorating the Great Exhibition Building in Hyde Park in 1851 was a lesson to all art professors they did not forget. The building itself had sprung from unprofessional heads, and the decoration of it necessarily went into novel hands. A place that had no bricks, or stone, or plaster, could not be beautified, it was thought; but Owen Jones showed them how it could: and from that day the taste of the public has grown in favour of strong colouring upon sound principles. Sometimes extravagant, of course, and sometimes feeble and inappropriate; but its tendency has been rapidly progressive, until neither church, hall, mansion, cottage, or country house is deemed fit for common use unless some attempt at ornament by colour is made.

Jones and Wyatt united in deploring the dissolution of what should never be separated, namely, the architect and decorator, just as Mr. Denison in his book last year complained that the function of the architect and builder had ceased to be united. In his essay on colour on the decorative arts, Owen Jones says, "In all ages but our own, the same ornaments, the same system of colouring which prevailed upon their buildings, pervaded all they did, even to their humblest utensils: the ornaments on a mummy case are analogous with those of the Egyptian temple; the painted vases of the Greeks are but the reflex of the paintings of their temples; the beautiful cushions and slippers of Morocco of the present day are adorned with similar ornaments, having the same colours as are to be found on the walls of the Alhambra. It is different with ourselves.

"We have no principles, no unity; the architect, the upholsterer, the paper-stainer, the weaver, the calico printer, and the potter, run each their independent course. Each struggles fruitlessly, each produces art without beauty, or beauty without intelligence. The architect, the natural head and chief of all who minister to the comforts and adornments of our homes, has abdicated his high office: he has been content to form the skeleton which it should also have been his task to clothe, and has relinquished to inferior and unguided hands the delicate modelling of the tissues, and the varied colouring of the surface."

In insisting on the employment of colour he asserted that—in spite of the opinions of the Royal Society of British Architects, "the stupendous monuments of the Egyptians, Greeks, Arabs, and other eastern civilizations, were covered, not in vain, with a most elaborate system of ornamentation requiring colour, in obedience to a *patient observation of nature's works*." We are not to be slavish imitators, but followers of those who discovered principles on which they acted, which principles run through all time. Principles that abide are discovered truths that no wise student can reject.

"He who should set about forming a new style for himself without regard to the past, would be like a student in astronomy who should reject the discoveries of Newton, and endeavour to work out every process for himself. Yet, on the other hand, where would astronomy be, if successive students had been content to receive Newton's discoveries as final truths instead of employing them as the bases of fresh research?"

Much more like this is scattered throughout the voluminous contributions Mr. Jones made public, but in one place he formulates the subject by propositions.

1. Colour assists the development of form, and distinguishes objects one from another.

2. Colour assists light and shade.

3. Use primary colours on small surfaces and in small quantities, balanced and supported by secondary and tertiary on the larger masses.

4. Use primary colours on the upper portions of objects; secondary and tertiary on the lower.

5. Primaries harmonize or neutralize each other in the proportion of 3 yellow, 5 red, and 8 blue (16): Secondaries, 8 orange, 13 purple, 11 green (32): Tertiaries, citrine (orange and green) 19, russet (orange and purple) 21, olive (green and purple) 24 (64). And then he proceeds to recite Field's Chromatic Equivalents, and Chevreul's Law of the Simultaneous Contrast of Colours.

These he reduced to axioms and discoursed upon them, showing their practical use to him in his labour at the Great Exhibition Building in 1851. In obedience to proposition 1, he intended to bring out the construction of the building that it should appear higher, longer, and more solid: 2, Colour each part so that light and shade should be assisted and peculiar forms more manifest: 3 and 4, Balance primary colours so that they harmonize with the varied contents of the building, of every imaginable hue. He succeeded marvellously: it was not perfect, for who could hope that a mere experiment would absolutely realize the proposals of their author.

Any one who remembers the period before 1851 will be able to understand the revolution of taste subsequently effected, but it is not known to all that the change is attributable to the indignant remonstrance of the architect of whom we speak. It was he who transformed the pattern-making for paper-hangings, partly by sarcasm and more by reason. And he did not abuse our country, for of France he says, "Here we have a French paper that has had a great run: it is a wall of strawberries! Now, in what are English papers more absurd? Beautiful as is the pattern and its manufacture and colour, it is offensive, because it violates the first of all rules—propriety."

He was soon called upon to produce patterns on his own idea of form, and hence has come all the varieties of diamond-shape, acorn-shape, half-egg shape, and the varying lines that edge, or shade, or surround. Paper-making factories were obliged to take blocks from houses such as Jackson and Graham, or Gillow's—the property of the decorator, and work them at the discretion of their owners, as to colour, shade, and on what paper. Never was such a thing known before. The maker dared not use the pattern in his own folio. They were special. Therefore the whole manufacturing interest tacked about, and leaving the old glories of pastoral pictures, sea pictures, and the thousand and one follies hitherto most successful, because alone, sought for artists who would compose designs in accordance with the change of fashion. Patterns had to be discarded by the hundred and made floors in the factory; the public saw the new light, and followed it, we think, too enthusiastically. We see nothing but beauty in having a wall covered with an imitation of climbing plants and flowers, and as Mr. Jones urged, there is no condemnation too strong, when any absurd violation of propriety is attempted. The calico-printer and the weaver, he complains, "violate our proposition at every step." We walk on flowers and tropical plants . . . . . have chintzes wound with roses in violent contortions . . . . . dress ladies in rose, shamrock, and thistle . . . . . print shirts with race-horse patterns, or faces of ballet-girls. The potter is as bad; without flowers he believes his art would not exist, and he puts them on every dish. "So runs the fashion of the present day: would that its sun were set, that we might awake to a more healthy dawn."

The potter left off his flowers, and so did the calico-printer, and the carpet-maker; the paper-stainer followed suit, and such a revolution in public taste ensued, that orders became troublesome from their increased numbers, and the transformation of style. Pattern books are now made in accordance with Mr. Jones' ideas. The monopolists of fashion do not require to make it indispensable that only their own blocks shall be used in their business, for the general trade has many excellent ones; but the change is solely owing to Mr. Jones' teaching and his persistent assertion of the superiority of the method he preached.

We must now refer to his favourite project, "the Schools of Design." Work such as he had done drew upon him, as has been stated, opposition and obloquy, but it also attracted sympathy and business. His active hands became full; and the man whose words were mighty, and whose demeanour most retiring, became invested with an authority that compelled him to assume the

position of chief instructor in those departments he had made his life's study.

He had a very direct form of speech. "Ornamentation results from architecture, but we have no guiding principle in design or unity, because the architect has abandoned his function. Architects should represent faithfully the wants, feelings, and faculties of our time; but as yet they have not sufficient knowledge."

Again, "We have all the works of the past for our inheritance. We may use the principles and knowledge derivable from them, but may not parody the results of those principles. From the works of Egypt we may learn how to symbolise; from those of Greece we may learn purity of form and grace of outline; from the Arabs and Indians perfection of form, harmony of colouring, and more especially the conventionality of natural forms; from the Moors, in addition, the great powers of geometrical combinations, and the immense value of the repetition of the most simple elements in producing grandeur and richness; and when fully impressed with this knowledge, have we not before us the whole range of Nature's works, furnishing suggestions of endless variety? See what Egyptians did with the lotus, the Greeks with the honey-suckle, the Romans with the acanthus, the Mediæval artists with the trefoil, the maple, the vine, ivy, and oak. Have the plants and flowers of every clime been gathered together in vain for the architect? Can they furnish him no hint for the development of new conventional forms?

These powers of instruction had been obtained at great labour and cost. We hear of him in Granada in 1834 labouring with M. Jules Goury in the study and sketching of the Alhambra. This splendid work appeared a few years after, and when the Crystal Palace Company undertook the transfer of the Exhibition Building from Hyde Park to Penge, he was made Director of Ornamentation, in which capacity he produced that most magnificent and costly Court—the Alhambra, now, alas! destroyed by fire, and probably never will be reformed.

After a residence of six months in the Alhambra, M. Jules Goury fell a victim to cholera, and Mr. Owen Jones at once returned to England, and in the following year commenced publishing the original drawings. In the spring of 1837 he revisited the Alhambra and completed his collection. To insure perfect accuracy, an impression of every ornament was taken either in plaster or with unsized paper; and from these casts the drawings were engraved, and the splendid volume is a record of "the peculiar sentiment which pervades the works of the Arabs." Gorgeous beyond description, it is an imperishable monument of the skill as well as the industry of this then young architect, who published it himself in 1842.

The story of his life is one of rising fame. Proud of his claim to be designated an architect, he adhered strictly to his interpretation thereof. Form and colour occupied almost his whole life. Publishers, such as Messrs. Longmans, gave him commissions to design sides for their superb editions; and De La Rue & Co. for patterns for blotting-cases, playing-cards, and other ornamental work in which they are supreme; and when he brought out his Alhambra book, there followed immediately, "Designs for Mosaic and Tesselated Pavements," and in 1844 he had engagements to decorate the pavements of new shops in Regent Street and elsewhere. He also exhibited a plan for decorating the Houses of Parliament, at the request of the Commissioners, and that included designs for the pavements of the halls and corridors. He also reformed the ornamental part of Messrs. Jay's then new premises. This brings us to the appointment of Superintendent of Works to the Great Exhibition and what grew out of it—the Crystal Palace—to perfect which he and Mr Digby Wyatt took a tour through the Continent.

The reader who shall visit the Crystal Palace must not forget that Owen Jones directed the whole of those internal arrangements of artistic production. His drawings in 1833 of Egyptian monuments are the foundation of the Court set apart for that country; and in its creation he had the great benefit of Mr. Bonomi's hearty co-operation, who had resided in Egypt ten years and visited every monument in the country. He describes the process pursued by the Egyptians in decorating the walls of the vast chambers, as it can be traced in the pictorial sketches and the unfinished works still preserved. It is practical, and may not be without interest:

"The wall was first chiselled as smooth as possible, the imperfections of the stone were filled up with cement or plaster, and the whole rubbed smooth and covered with a coloured wash; lines were then ruled perpendicularly and horizontally with red colour, forming squares all over the wall, corresponding with the proportions of the figures to be drawn upon it. The subjects of the painting of the hieroglyphics were then drawn on the wall with a *red line*, most probably by the chief or scribe, or by some inferior artist, from a document divided into similar squares: then came the chief artist, who went over every figure and hieroglyphic with a *black line*, and a firm and steady hand, giving expression to each curve,—deviating here, and confirming there, the former red line. The line thus traced was followed by the sculptor. . . . . The next process was to paint the figure in the prescribed colours; and in some cases the painted line deviates from the sculptured, showing that the painter was the more important workman. . . . . Instances of the whole of this are in the tombs at Thebes and in that called Benzoni."

The Greek court derived its arrangement from Mr. Penrose; Mr. Jones decorated all the ceilings, and did all the colouring. But the attention of the architect centered in the Alhambra court. From the casts in plaster and in unsized paper, the ornaments were carved, moulded, cast, and fixed, in counterpart of the Granada original. One cannot repress the conviction that in the Mohammedan form and colour, Mr. Jones realized the highest example he could appreciate; and we believe he would rather have had no profit for all his labour at Sydenham, had any circumstance thwarted his cherished desire to reproduce as far as space and conditions would allow, the glories of Granada.

"On the walls of the Hall of the Two Sisters in the Alhambra, are verses applicable, above all others, to the opening of the Crystal Palace." So felt the artist, and here we must quote:

"Look attentively at my elegance, thou wilt reap the benefit of a commentary on education.

"For, by Allah! the elegant buildings by which I am surrounded surpass all other buildings in the propitious omen attending their foundation.

"Apartments are there enfolding so many wonders that the eyes of the spectator remain for ever fixed upon them; provided he be gifted with a mind for their estimation.

"How many delightful prospects—how many objects in the contemplation of which a highly gifted mind finds the gratification of its utmost wishes.

. . . . . .

"This is a palace of transparent crystal: those who look at it imagine it to be a boundless ocean.

"Indeed, we never saw a palace more lofty than this in its exterior, or more brilliantly decorated in its interior, or having more extensive apartments.

"And yet I am not alone to be wondered at, for I overlook in astonishment a garden, the like of which no human eyes ever saw."

There is a pleasure in observing the play of sentiment, and the honest glow of praise, with which Owen Jones recites these lines; a reverence and dignity never dissociated from the Mohammedan faith, and a skilful adaptation to the circumstances of our time, which ended in producing the fairy structure on the Surrey heights. But the architect's zeal hits hard. Tracing the worship that demanded architectural expression, he shows how that "Egypt worshipped nature, Greeks materialism and beauty, Rome the material without the refinement. Then came Christian art with its hour of faith, its day of joy and intoxication, its time of lingering disease and death. At its acme, science and art, religion and love, ministered to it under the influence of faith, and no style has been more beautiful, none more glorious. It wore itself out through feebleness and neglect, and the Reformation destroyed it altogether. . . . .

"But if the Reformation destroyed religious architecture . . . there has arisen a religion more powerful whose works equal, nay, surpass, all that the Egyptians, Greeks, or Romans ever conceived.

"Mammon is the god: Industry and Commerce the high priests. Devoid of poetry, feeling, faith, we have abandoned Art for her sterner sister Science. And as among the ancients we may trace their chronicles on their temples, or with the Romans in luxury and conquest. So, when this age shall have passed away, will the works which have resulted from the union of Science, Commerce, and Industry, to the utter exclusion of Art, be handed down to posterity to assign our rank in the scale of departed nations."

None the less important are these words from the fact that since they were written much has been done to deliver us from the reproach they convey: they are of tremendous import as warnings that should bid us hold fast to the binding of our nature, not only so as to be in harmony with ourselves, but with the Past, and the Future, and the Divine.

We need not go through the whole of the valuable matter left in fragments by Mr. Jones particularly, because only a few months back we noticed the career of one who was almost his brother, Mr. Digby Wyatt, wherein much was said quite appropriate to this memoir; nor have we space to spare. His immortal book is the "Grammar of Ornament," consisting of 1000 imperial folio engravings with descriptions. It is a development and a history of art; this is proved by the enumeration of the titles of its twenty divisions:—1. Ornaments of savage tribes: 2. Egyptian ornament: 3. Assyrian and Persian

ornament: 4. Greek ornament: 5. Pompeiian ornament: 6. Roman: 7. Byzantine: 8. Arabian: 9. Turkish: 10. Moresque, from the Alhambra: 11. Persian: 12. Indian: 13. Hindoo: 14. Chinese: 15. Celtic: 16. Medieval, including manuscripts: 17. Renaissance: 18. Elizabethan: 19. Italian: 20. Leaves of Flowers from Nature. These are in almost infinite variety; many sheets contain a score of examples. No words can pretend to give an idea of the richness and value of this production.

St. James's Hall is about the last of his important works, but to his last days he was consulted by all who sought the ablest counseller and the finest wisdom. Conscientious and retiring he maintained his position at Argyle Place all his life since his settlement in London, avoiding the glitter of display, and ever accessible to all, and by all beloved.

One more paragraph, and we end.

The diffusion of artistic taste and knowledge since the commencement of the labours of the Exhibition Commissioners gives interest to many observations that then fell on listless ears. Owen Jones describes technically the distinctive characteristics of various national tastes as they contributed to the Exhibition, in a Catalogue of what was purchased and sent to South Kensington.

"In the Indian collection we find no struggle after an effect; every ornament arises quietly and naturally from the object decorated, inspired by some true feeling or embellishing some real want. The same guiding principle is present everywhere—in the embroidered and woven garment tissues, as in the humblest earthen vase.

"There are here no carpets worked with flowers whereon the feet would fear to tread, no furniture the hand would fear to grasp, no superfluous and useless ornament, which a caprice has added and an accident might remove.

"The patterns of their shawls, garments, and carpets, are harmonious and effective from the proper distribution of form and colour; they do not require to be heightened by strong and positive contrasts.

"There are no artificial shadows, no highly wrought imitations of natural flowers . . . struggling to stand out from the surfaces on which they are worked; but conventional representations sufficiently suggestive to convey the intended image to the mind without destroying the unity of the object they are employed to decorate. With them the construction is decorated: decoration is never, as with us, purposely constructed.

"With them beauty of form is produced by lines growing out one from the other in gradual undulations: no excrescences: nothing could be removed and leave the design equally good or better. General forms are first cared for: these are subdivided and ornamented by general lines, the interstices filled in with ornament, which is again subdivided and enriched for closer inspection.

"In conventional foliage the forms flow from a parent stem so as to cover the space to be filled, with exquisite skill; we are never offended by random introduction of ornament: every flower, however distant, can be traced to its branch and root.

"In the management of colour the Easterns are perfect; brilliant colours harmonize by natural instinct; it is difficult to find a discord; . . . . when gold ornaments are used on a coloured ground in large masses the ground is darkest: where more thinly the ground is lighter and more delicate. When a gold ornament alone is used on a coloured ground, the colour is carried into it by ornaments or hatchings worked in the ground colour on the gold itself; when, on the contrary, ornaments in a colour are on a gold ground, the ornaments are separated . . . . by an edging of a darker colour to prevent the gold ground overpowering the ornament."

Lastly, Mr. Jones cautions the student against imitations, reminding him "that these objects are for instruction, and that what faithfully represents the wants, sentiments, and faculties of one people is inadequate to another people under different conditions.

"The principles belong to us; not the results. The reproductions of an Indian style in this country would be a most flagrant evil."

Besides the Grammar of Ornament, which may be said to be entirely a book of principles, Owen Jones issued in 1864 his volume of one thousand and one "Initial letters"—a treasure to a die-sinker or a connoisseur—and also another containing "Seven Hundred Monograms." These necessarily cannot be described although worthy of that and every other commendation. We have only to record one more great work and that is illustrious—the "Examples of Chinese Ornaments," which was published in 1867. It is an exquisite volume showing the various forms of art to be seen in the Collection of the spoils of the Pekin Summer Palace when it was taken by the English in the war with China some fifteen years ago. For drawing, colour, and teaching, it is especially worthy of regard, now that the floral and the curve are becoming favourite forms of ornament and acceptable tokens of taste.

At the age of 65, Owen Jones died at his residence, Argyll Place, Regent Street, on Sunday, April 19, 1874. His friends followed his remains to Kensal Green on the following Saturday, among whom was the President of the Royal Society and other distinguished men, who not only appreciated his great endowments, but loved him as a man.

W. S. C.

MODERN SCIENTIFIC PRINCIPLES.

By Professor Tyndall.

PROFESSOR TYNDALL delivered his address at Birmingham as President of the Midland Institute. His topic was the law discovered by Dr. Joule which governs the conversion of heat into force, from which has been deduced the doctrine of the conservation of energy, and Dr. Mayer's illustrations of the same subject. From this Professor Tyndall passed to some considerations of the scientific difficulties surrounding the belief in the existence of a free human soul, and to observations upon the doctrine of free will. He commenced, after some preliminary observations, by remarking that the celebrated Robert Boyle regarded the universe as a machine; Mr. Carlyle prefers regarding it as a tree. But the two conceptions are not so much opposed to each other after all. In one essential particular they, at all events, agree. They equally imply the interdependence and harmonious interaction of parts, and the subordination of the individual powers of the universal organism to the working of the whole. Never were the harmony and interdependence just referred to so clearly recognised as now. Our insight regarding them is not that vague and general insight to which our fathers had attained, and which, in early times, was more frequently affirmed by the synthetic poet than by the scientific man. The interdependence of our day has become quantitative—expressible by numbers—leading, it must be added, directly into that inexorable reign of law which so many people regard with dread. In the domain now under review men of science had first to work their way from darkness into twilight, and from twilight into day. There is no solution of continuity in science. It is not given to any man, however endowed, to rise spontaneously into intellectual splendour without the parentage of antecedent thought. Great discoveries grow. Here, as in other cases, we have first the seed, then the ear, then the full corn in the ear, the last member of the series implying the first. After referring to the discoveries of Newton, Keplar, Faraday, and others, Professor Tyndall paid a high tribute of admiration to the names of Julius Robert Mayer and James Prescott Joule. He said:—"When Dr. Joule first proved that a weight of one pound, falling through a height of 772ft., generated an amount of heat competent to warm a pound of water one degree Fahrenheit, and that in lifting the weight so much heat exactly disappeared he broke an Emersonian 'circle,' releasing by the act an amount of scientific energy which rapidly overran a vast domain. Helmholtz, Clausius, Thomson, Rankine, Regnault, Favre, and other illustrious names are associated with the conquests since achieved and embodied in the great doctrine known as the 'Conservation of Energy.' This doctrine recognises in the material universe a constant sum of power made up of items among which the most Protean fluctuations are incessantly going on. It is as if the body of nature were alive, the thrill and interchange of its energies resembling those of an organism. The parts of the 'stupendous whole' shift and change, augment and diminish, appear and disappear, while the total of which they are the parts remains quantitatively immutable (immutable, because when change occurs it is always polar); *plus* accompanies *minus*, gain accompanies loss, no item varying in the slightest degree without an absolutely equal change of some other item in the opposite direction. The sun warms the tropical ocean, converting a portion of its liquid into vapour, which rises in the air and is recondensed on mountain heights, returning in rivers to the ocean from which it came. Up to the point where condensation begins an amount of heat exactly equivalent to the molecular work of vaporisation and the mechanical work of lifting the vapour to the mountain-tops has disappeared from the universe. What is the gain corresponding to this loss? It will seem when mentioned to be expressed in a foreign currency. The loss is a loss of heat; the gain is a gain of distance, both as regards masses and molecules. Water which was formerly at the sea-level has been lifted to a position from which it can fall; molecules which had been locked together as a liquid are now separate as vapour which can recondense. After condensation gravity comes into effectual play,

pulling the showers down upon the hills, and the rivers thus created through their gorges to the sea. Every raindrop which smites the mountain produces its definite amount of heat; every river in its course develops heat by the clash of its cataracts and the friction of its bed. In the act of condensation, moreover, the molecular work of vaporisation is accurately reversed. Compare, then, the primitive loss of solar warmth with the heat generated by the condensation of the vapour, and by the subsequent fall of the water from cloud to sea. They are mathematically equal to each other. No particle of vapour was formed and lifted without being paid for in the currency of solar heat; no particle returns as water to the sea without the exact quantitative restitution of that heat. There is nothing gratuitous in physical nature—no expenditure without equivalent gain, no gain without equivalent expenditure. With inexorable constancy the one accompanies the other, leaving no nook or crevice between them for spontaneity to mingle with the pure and necessary play of natural force. Has this uniformity of nature ever been broken? The reply is 'Not to the knowledge of science.' What has been here stated regarding heat and gravity applies to the whole of inorganic nature. Let us take an illustration from chemistry. The metal zinc may be burnt in oxygen, a perfectly definite amount of heat being produced by the combustion of a given weight of the metal. But zinc may also be burnt in a liquid which contains a supply of oxygen—in water, for example. It does not in this case produce flame or fire, but it does produce heat which is capable of accurate measurement. But the heat of zinc burnt in water falls short of that produced in pure oxygen, the reason being that to obtain its oxygen from the water the zinc must first dislodge the hydrogen. It is in the performance of this molecular work that the missing heat is absorbed. Mix the liberated hydrogen with the oxygen, and cause them to recombine, the heat developed is mathematically equal to the missing heat. Thus, in pulling the oxygen and hydrogen asunder an amount of heat is consumed which is accurately restored by their reunion. This may be taken as prefatory to a few remarks upon the voltaic battery. It is not my design to dwell upon the technic features of this wonderful instrument, but simply to illustrate by means of it the further play of the principle of equivalence and conservation, and to show the varying shapes which a given amount of energy can assume while maintaining unvarying quantitative stability. When that form of power which we call an electric current passes through Groves' battery; zinc is consumed in acidulated water, and in the battery we are able so to arrange matters that when no current passes no zinc shall be consumed. Now, the current, whatever it may be, possesses the power of generating heat outside the battery. We can fuse with it iridium, the most refractory of metals, or we can produce with it the dazzling electric light, and that at any terrestrial distance from the battery itself. We will now, however, content ourselves with causing the current to raise a given length of platinum wire, first to a blood heat, then to redness, and finally to a white heat. The heat under these circumstances generated in the battery by the combustion of a fixed quantity of zinc is no longer constant, but it varies inversely as the heat generated outside. If the outside heat be nil, the inside heat is a maximum; if the external wire be raised to a blood-heat, the internal heat falls slightly short of the maximum. If the wire be rendered red-hot, the quantity of missing heat within the battery is greater and if the external wire be rendered white-hot, the defect is greater still. Add together the internal and external heat produced by the combustion of a given weight of zinc, and you have an absolutely constant total. The heat generated without is so much lost within, the heat generated within is so much lost without, the polar changes already adverted to coming here conspicuously into play. Thus, in a variety of ways, we can distribute the items of a never-varying sum, but even the subtle agency of the electric current places no creative power in our hands. Instead of generating external heat we may cause the current to effect chemical decomposition at a distance from the battery. Let it, for example, decompose water into oxygen and hydrogen. The heat generated in the battery under these circumstances by the combustion of a given weight of zinc falls short of what is produced when there is no decomposition. How far short? The question admits of a perfectly exact answer. When the oxygen and hydrogen recombine, the heat absorbed in the decomposition is accurately restored, and it is exactly equal in amount to that missing in the battery. We may, if we like, bottle up the gases, carry in this form the heat of the battery to the Polar Regions, and liberate it there. The battery, in fact, is a hearth on which fuel is consumed, but the heat of the combustion, instead of being confined in the usual manner to the hearth itself, may be first liberated at the other side of the world. In my youth I thought an electro-magnetic engine which was shown to me a veritable perpetual motion—a machine, that is to say, which performed work without the expenditure of power. Let us consider the action of such a machine. Suppose it to be employed to pump water from a lower to a higher level. On examining the battery which works the engine we find that the zinc consumed does not yield its full amount of heat. The quantity of heat thus missing within is the exact thermal equivalent of the mechanical work performed without. Let the water fall again to a lower level, it is warmed by the fall. Add the heat thus produced to that generated by the friction, mechanical and magnetical, of the engine, we thus obtain the precise amount of heat missing in the battery. All the effects obtained from the machine are thus strictly paid for; this 'payment for results' being, I would repeat, the inexorable method of nature. No engine, however subtly devised, can evade this law of equivalence, or perform on its own account the smallest modicum of work. The machine distributes, but it cannot create. Is the animal body, then, to be classed among machines? When I lift a weight, or throw a stone, or climb a mountain, or wrestle with my comrade, am I not conscious of actually creating and expending force? Let us look to the antecedents of this force. We derive the muscle and fat of our bodies from what we eat. Animal heat you know to be due to the slow combustion of this fuel. My arm is now inactive, and the ordinary slow combustion of my blood and tissue is going on. For every grain of fuel thus burnt a perfectly definite amount of heat has been produced. I now contract my biceps muscle without causing it to perform external work. The combustion is quickened and the heat is increased, this additional heat being liberated in the muscle itself. I lay hold of a 56 lb. weight, and by the contraction of my biceps lift it through the vertical space of a foot. The blood and tissues consumed during this contraction have not developed in the muscle their due amount of heat. A quantity of heat is at this moment missing in my muscle which would raise the temperature of an ounce of water somewhat more than one degree Fahrenheit. I liberate the weight, it falls to the earth, and by its collision generates the precise amount of heat missing in the muscle. My muscular heat is thus transferred from its local hearth to external space. The fuel is consumed in my body, but the heat of combustion is produced outside my body. The case is substantially the same as that of the voltaic battery when it performs external work or produces external heat. All this points to the conclusion that the force we employ in muscular exertion is the force of burning fuel, and not of creative will. In the light of these facts the body is seen to be as incapable of generating energy without expenditure as the solids and liquids of the voltaic battery. The body, in other words, falls into the category of machines. We can do with the body all that we have already done with the battery—heat platinum wires, decompose water, magnetise iron, and deflect a magnetic needle. The combustion of muscle may be made to produce all these effects, as the combustion of zinc may be caused to produce them. By turning the handle of a magneto-electric machine, a coil of wire may be caused to rotate between the poles of a magnet. As long as the two ends of the coil are unconnected we have simply to overcome the ordinary inertia and friction of the machine in turning the handle. But the moment the two ends of the coil are united by a thin platinum wire a sudden addition of labour is thrown upon the turning arm. When the necessary labour is expended its equivalent immediately appears. The platinum wire glows. You can readily maintain it at a white heat, or even fuse it. This is a very remarkable result. From the muscles of the arm, with a temperature of 100°, we extract the temperature of molten platinum, which is many thousand degrees. The miracle here is the reverse of that of the burning bush mentioned in Genesis. There the bush burned but was not consumed, here the blood is consumed but does not burn. The similarity of the action with that of the voltaic battery when it heats an external wire is too obvious to need pointing out. When the machine is used to decompose water, the heat of the muscle, like that of the battery, is consumed in molecular work, being fully restored when the gases recombine. As before, also, the transmuted heat of the muscles may be bottled up, carried to the Polar Regions, and there restored to its pristine form. The matter of the human body is the same as that of the world around us, and here we find the forces of the human body identical with those of inorganic nature. Just as little as the voltaic battery is the animal body a creator of force. It is an apparatus exquisite and effectual beyond all others in transforming and distributing the energy with which it is supplied, but it possesses no creative power. Compared with the notions previously entertained regarding the play of 'vital force,' this is a great result. The problem of vital dynamics has been described by a competent authority as the 'grandest of all.' I subscribe to this opinion, and honour correspondingly the man who first successfully grappled with the problem. He was no pope in the sense of

being infallible, but he was a man of genius whose work will be held in honour as long as science endures. I have already named him in connection with our illustrious countryman, Dr. Joule. Other eminent men took up this subject subsequently and independently; but all that has been done hitherto enhances, instead of diminishing, the merits of Dr. Mayer. Consider the vigour of his reasoning. 'Beyond the power of generating internal heat, the animal organism can generate heat external to itself. A blacksmith by hammering can warm a nail, and a savage by friction can heat wood to its point of ignition. Unless, then, we abandon the physiological axiom that the animal body cannot create heat out of nothing, we are driven to the conclusion that it is the total heat, within and without, that ought to be regarded as the real calorific effect of the oxidation within the body.' Mayer, however, not only states the principle, but illustrates numerically the transfer of muscular heat to external space. A bowler who imparts a velocity of 30 ft. to an 8 lb. ball consumes in the act 1-10th of a grain of carbon. The heat of the muscle is here distributed over the track of the ball, being developed there by mechanical friction. A man weighing 150 lb. consumes in lifting his own body to a height of 8 ft. the heat of a grain of carbon. Jumping from this height the heat is restored. The consumption of 2 oz. 4 drs. 20 grs. of carbon would place the same man on the summit of a mountain 10,000 ft. high. In descending the mountain an amount of heat equal to that produced by the combustion of the foregoing amount of carbon is restored. The muscles of a labourer whose weight is 150 lb. weigh 64 lb. When dried they are reduced to 15 lb. Were the oxidation corresponding to a day labourer's ordinary work exerted on the muscles alone, they would be wholly consumed in 80 days. Were the oxidation necessary to sustain the heart's action concentrated on the heart itself, it would be consumed in eight days. And if we confine our attention to two ventricles, their action would consume the associated muscular tissue in three days and a half. With a fulness and precision, of which this is but a sample, did Mayer, between 1842 and 1845, deal with the great question of vital dynamics. We place, then, food in our stomachs as so much combustible matter. It is first dissolved by purely chemical processes, and the nutritive fluid is poured into the blood. Here it comes into contact with atmospheric oxygen admitted by the lungs. It unites with the oxygen as wood or coal might unite with it in a furnace. The matter products of the union, if I may use the term, are the same in both cases—viz., carbonic acid and water. The force products are also the same—heat within the body, or heat and work outside the body. Thus far every action of the organisms belongs to the domain either of physics or of chemistry. But you saw me contract the muscle of my arm. What enabled me to do so? Was it or was it not the direct action of my will? The answer is, the action of the will is mediate, not direct. Over and above the muscles the human organism is provided with long whitish filaments of medullary matter, which issue from the spinal column, being connected by it on the one side with the brain, and on the other side losing themselves in the muscles. Those filaments or cords are the nerves, which you know are divided into two kinds, sensor and motor, or, if you like the terms better, afferent and efferent nerves. The former carry impressions from the external world to the brain; the latter convey the behests of the brain to the muscles. Here, as elsewhere, we find ourselves aided by the sagacity of Mayer, who was the first to clearly formulate the part played by the nerves in the organism. Mayer saw that neither nerves nor brain, nor both together, possessed the energy necessary to animal motion; but he also saw that the nerve could lift a latch and open a door by which floods of energy are let loose. 'As an engineer,' he says with admirable lucidity, 'by the motion of his finger in opening a valve or loosening a detent can liberate an amount of mechanical energy almost infinite compared with its exciting cause, so the nerves, acting on the mucles, can unlock an amount of power out of all proportion to the work done by the nerves themselves.' The nerves, according to Mayer, pull the trigger, but the gunpowder which they ignite is stored in the muscles. This is the view now universally entertained. The quickness of thought has passed into a proverb, and the notion that any measurable time elapsed between the infliction of a wound and the feeling of the injury would have been rejected as preposterous 30 years ago. Nervous impressions, notwithstanding the results of Haller, were thought to be transmitted, if not instantaneously, at all events with the rapidity of electricity. Hence, when Helmholtz, in 1851, affirmed, as the result of experiment, nervous transmission to be a comparatively sluggish process, very few believed him. His experiment may now be made in the lecture-room. Sound in air moves at the rate of 1,100 ft. a second; sound in the water moves at the rate of 4,000 ft. a second; light in either moves at the rate of 190,000 miles a second, and electricity in free wires moves probably at the same rate. But the nerves transmit their messages at the rate of only 70 ft. a second, a progress which, in these quick times, might well be regarded as intolerably slow. Mr. Gore has produced, by electrolysis, a kind of antimony which exhibits an action strikingly analogous to that of nervous propagation. A rod of this antimony is in such a molecular condition that when you scratch or heat one end of the rod the disturbance propagates itself before your eyes to the other end, the onward march of the disturbance being announced by the devolopment of heat and fumes along the line of propagation. In some such way the molecules of the nerves are successively overthrown; and if Mr. Gore could only devise some means of winding up his exhausted antimony, as the nutritive blood winds up exhausted nerves, the comparison would be complete. The subject may be summed up, as Du Bois-Reymond has summed it up, by reference to the case of a whale struck by a harpoon in the tail. If the animal were 70 ft. long, a second would elapse before the disturbance could reach the brain. But the impression after its arrival has to diffuse itself and throw the brain into the molecular condition necessary to consciousness."

ICE-MAKING.

FREEZING by art is one of the products of civilization that is little understood in theory but much valued for its results. We will endeavour to recite the story of its origin and progress, and supply such general information as every one should possess. Mr. Vallance of Brighton—a name familiar to all who have visited the London-on-the-Sea tells us that in 1824 it had long been known that evaporation abstracts or carries off heat from liquids, and that in 1725 Dr. Cullen discovered that removing the pressure of the atmosphere facilitated evaporation to a degree which enabled him to freeze water even in summer; and that in 1777 Mr. Nairne discovered that introducing sulphuric acid—oil of vitriol—into an exhausted receiver absorbed or took up aqueous vapour from, and dried, rarefied air; and that in 1810 Professor Leslie utilised that principle by freezing quantities of water about a pound or one-and-a-half pound in weight, but could not congeal larger quantities. Vallance put both these aside by his method of combining both through the agency of a current of dry rarefied air which he caused to impinge upon and pass over the surface of the water to be frozen. He poured water into a very large flat-bottomed shallow vessel in order to obtain the greatest area of surface. From that surface he removed the atmospheric pressure by producing a vacuum in it that only supported an inch of mercury: he then caused a current of cooled air to pass over the surface so as to carry off the vapour as fast as it was formed and rose, whereby he carried off caloric from the water to a degree that caused congelation. On the frozen basis he poured other water and repeated the process until he had obtained all he required.

Not content with his first essay he immediately set to work and elaborated his ideas and constructed machinery to complete his improved methods of obtaining medical, chemical, and mechanical advantageous effects with less labour, and greatly augmented results.

But in 1834, Mr. Jacob Parkins, of Fleet Street, London, constructed apparatus which aimed at superseding both Vallance and Leslie. He says, "It is well known that by evaporating volatile fluids from the surfaces of vessels containing other fluids, the caloric of the latter fluids is reduced, and cools down the temperature: but in so evaporating volatile fluids the same is lost: beside which the process on a large scale is very expensive. He therefore re-uses the volatile fluids by a method of condensation and by conducting them back until they are spent."

Another ten years elapsed and Mr. Masters, a confectioner of Upper Charlotte Street, St. Pancras, made a still more perfect machine of peculiar combination and arrangement of parts, whereby freezing, cooling, churning, and ice preserving, might be conjointly and simultaneously conducted. Ice-creams and water-ices could be beaten up while being frozen. This brings us to present times; the many inventions which have followed only extend the general principle. Mr. Kingsford, of Essex Street, Strand, made a new machine in 1851: and Mr. Newton patented soon after, for a client, what appears to have been a much better apparatus: and upon improved scientific data the result of many experiments and much care, that had better be briefly discribed. It consisted essentially of a condensing engine; of receivers or reservoirs into which air could be forced; of an engine to drive the condenser, of pumps to inject jets of water into the condensing engine to absorb the heat disengaged by the air as compressed, and pumps to

inject the uncongealable liquid into the expanding engine that its heat might be absorbed by the expanding air, and a refrigerating chamber. He claimed the invention of "diffusing jets" in the condensing engine; no doubt of its ingenuity can exist; still the main principle was not affected. It was an apparatus, and an apparatus only; and one that did not in 1851 satisfy any, although the value of the apparatus could not be disputed.

Ammoniacal salts have often been looked upon as the most suitable elements in producing ice, and several indirect or rather incidental clauses are to be found in the several patents bearing upon this subject. As yet we have not been able to accept the idea that such a selection would be wise; nor would it be prudent to say we never shall discover methods in that direction that will meet our wants.

Mr. Reece made a prominent mark in his 1867 invention, in that it assumed a more practical form. By this apparatus he designed to effect the continuous distillation and rectification of dilute solution of ammonia upon the separative principle by means of a condenser and refrigerator. The first specification contained too extensive a claim, and the "disclaimer" is scarcely strong enough. The strength of this patent lay more in the diligence exercised in bringing it before the public, and supplying requirements as they arose.

Once more,—Mr. Welch of Harrow, took out letters in 1867, for producing ice economically and simply by the evaporation of ether or other similar hydro-carbons, and condensing the result. The only novelty he claims is "the combination of parts and of mechanism" and the like. We name it to show that gradually the tendency grew to accept ether as the best substance for anything like extensive operations, and that we have illustrated in West's machine (Fig 2) on next page.

We are able to illustrate two forms of ice-making machines, the one for family and hotel use; the other of indefinite capacity for making block ice. These have been selected because after a long and patient investigation of the merits of various inventions by government officials, they are proved to be the most perfect, and have obtained the Government patronage.

The action of the hand ice machine (Fig. 1) is based upon the fact that water can be frozen in a vacuum by rapid evaporation. For this purpose, vessels containing the water for freezing, are placed over a small tank of common sulphuric acid, in communication with an air pump. On working the pump, the water is caused to vaporise, the evaporation being asserted by the acid, which, having a powerful affinity for water, absorbs the moisture as it rises, until the water is frozen. One change of acid will make forty or fifty decanters, or twenty or thirty basins of ice without renewing.

The method of operation is simplicity itself. The machine being examined, the thumb-screw P is removed, and a lead funnel inserted. The cocks A A are turned on till the marker is at O (open): pour into the body of the machine 5¼ pints of

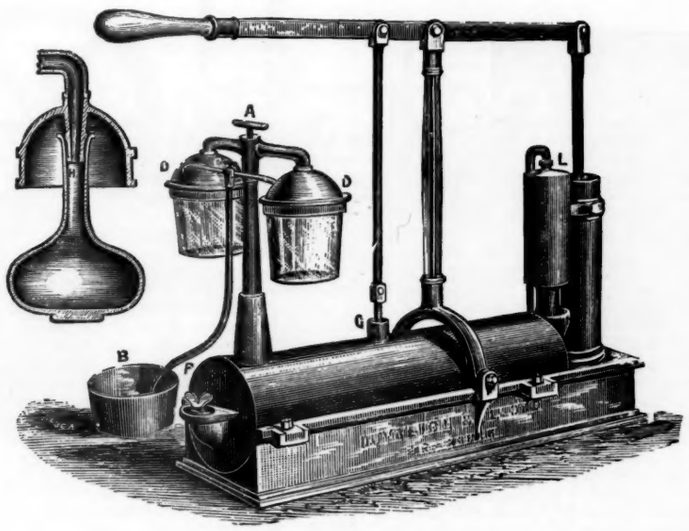

Fig. 1.

best white sulphuric acid, and remove the funnel; screw the plug P tight into its place, pour thick boiled oil on the top of it, and also in the other parts. Turn the cocks A A and pump, say 25 strokes, and go on until a slight resistance ensues, for that indicates a good vacuum. Place a glass basin or decanter under one of the bells, pressing the rim tight against the washer of india rubber, which has been carefully fixed under the bell while the cock is turned; the air will then be heard rushing from the basin into the machine. Another basin or bell is applied and both are held up by atmospheric pressure. Place the end of the syphon pipe B into a basin of clean water, turn the taps and admit a small quantity of water, about ¼ of an inch in depth in each; shut the cock and pump. The water will soon begin to bubble and when it becomes violent the pumping should be more gentle. The bottom of the basin will soon be covered with ice, and the operation is repeated by further small quantities of water until the basin is full. The cooling of water and the making of ice are simultaneous operations. This invention really includes most of the principles propounded in theory by previous scientific students, and puts into practice what they did not; or when it was attempted did very imperfectly. Messrs Davenport, of 99, High Holborn, have performed a service to the world in bringing this little machine to perfection; and it is not surprising to hear of its acceptance on the Continent, and in the other hemisphere.

Mr. West's patent (Fig. 2) is under special agreement worked by Messrs. Davenport for the purpose of producing any quantity or variety of ice. The illustration on next page is a machine designed for the manufacture of transparent block ice, and it can go on working for ever; no chemical ingredient is imported into the ice; on the contrary the ice is purer than the water of which it is made; and when it is melted distilled water is obtained. The ice is harder and more transparent than the best Norwegian natural ice, and is produced for five shillings a ton, including labour and steam charges; and if steam could produce a surplus stock there would be no necessity for the use of natural ice. This is the ever present teaching. Art and Nature are at one in the ministration to human comfort and want; but nature has no culture, and art is liable to have too much. Man has the difficulty of effecting their harmony, and unto him the Maker of all has committed the responsibility of reconciliation.

Notwithstanding that every winter large quantities of ice are collected for summer use, the price it brings in the market not only gives good incomes to those engaged in the trade, but natural ice is likewise imported from Norway, &c. to the extent of 50,000 tons annually, employing a large amount of shipping and capital, with profitable results to those engaged in the trade, from the very high price ice commands, even in our home-markets. If such are the facts of the trade in this country the establishment of ice manufactories in our principal industrial

centres and resorts of the pleasure-seeking population cannot fail, with proper management, to become a safe and highly lucrative business.

And such a result is much to be desired. The perils of Norway waters are exciting and profitable; they charm also. But if British mechanism can find a way by which the dwellers in Italy and those at Buenos Ayres can obtain ice without cartage from the fiords of the grand old Norse land, so much the better for mankind.

Sulphurous acid has been the sponsor for a multitude of inventors in every department of scientific manipulation, and it is not, in the face of what has been above stated, in the least surprising that many have only been "provisionally protected." Mr. Reece claimed this in 1865, under the title "Improvements in obtaining and applying sulphurous acid, and in apparatus used therein." He could not claim much concerning the acid, and he did not claim much for the apparatus. Of course the "liquid sulphurous acid obtained, produces an intense cold on its conversion into gas," and no doubt might be used "for the purposes of refrigeration and condensation." It was apparatus only that could be protected, and that consisted of a refrigerator, a gasifier, and a condenser. The first was two coils of piping, one in the other; the second an air-tight lead-lined vessel containing "a worm of lead coiled from top to bottom as closely as possible," each coil having a syphon "to collect the sulphurous acid condensed, made to irrigate the coil below," and having an inlet and an outlet pipe: the last was a coil of piping attached to a receiver. The refrigerator and condenser were put into separate vessels containing freezing mixtures.

The outer coil of the refrigerator was connected with the bottom of the coil in the gasifier, and the top of that coil to the inlet of the condenser, the outlet of which communicates with the inner pipe of the refrigerator. The condenser is placed over the gasifier; the receiver was connected to its inlet pipe through which flowed the liquid sulphurous acid, distributing it in a thin stream over the coil, producing intense cold and converting it into gas that escapes through the outer pipe.

There is really nothing new in all this: the idea belonged to a previous century, and could not be monopolised.

That indefatigable pioneer of modern medical science—as he is regarded, and with much reason—Dr. B. W. Richardson, very soon applied his discoveries respecting the properties of ether to this business of refrigeration; and although he made no particular mark on the subject, he undoubtedly opened a way for others, which has been found a profitable one. His "provisional protection" is entitled "Improvements in the means of

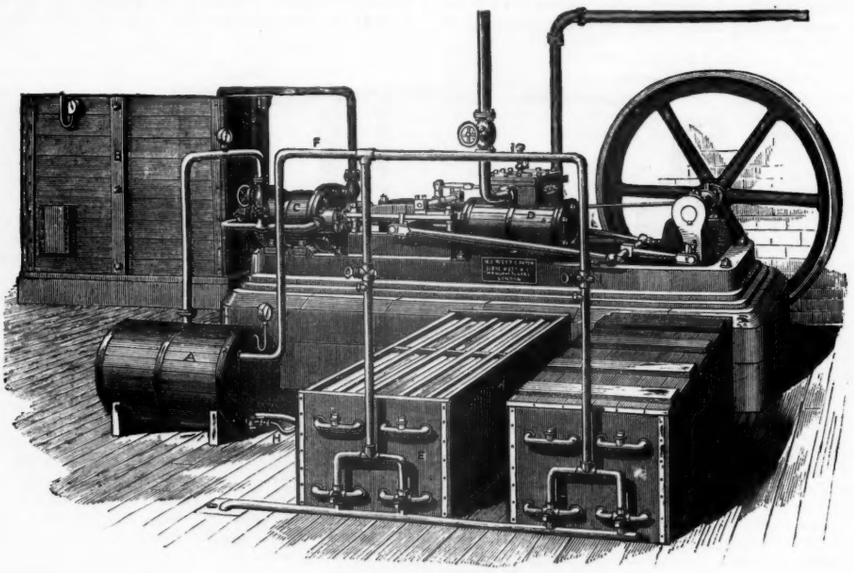

Fig. 2.

and apparatus for refrigerating or freezing liquids, and for producing ice." The cold is produced "by the contact of pulverized spray of volatile liquid," namely ether, or volatile hydrocarbons or the hydrocarbon products from gasworks; and the chief object is "to supply a portable apparatus for the purpose of refrigerating or freezing small quantities of liquid. This contained the great principle since triumphant, and is illustrated by the machine (fig. 2) of West's (Davenport, 99 High Holborn), but Dr. Richardson's idea never was patented and only had its application in wine coolers for private homes or for hotels, and then only to a small extent. The fact is, the public must depend on the manufacturer, because all or nearly so of the appliances and principles are virtually without patents that can exclude an outsider.

Mr. West's invention of 1870 was "designed for the more economical production and application of cold resulting from the evaporation of volatile liquids in vacuo, and has reference to an improved method of utilizing the cooling properties. A vacuum is produced by the ordinary means within a serpentine or other tube or tubes of suitable section communicating with a separate vessel containing the ether or other volatile liquid, and therefore cold vapour ascending from the volatile liquid passes through the tube or tubes which are surrounded to be refrigerated. The liquid is caused to circulate outside the tube or tubes in a contrary direction to the vapour within, and this principle is further extended by the use of other tubes.

In the same year Mr. Alex. Clerk, on behalf of a French client, claimed for improvements in the production of ice, and for apparatus based on modern principle, viz., the absorption of heat by the evaporation of volatile liquids in vacuo; but preferred hydrochloric ether (chloride of ethyle which boils at 54° Fahrenheit), he also applies vinous and methylic ethers and a dozen varieties of methyl and half a dozen other substances that boil at low temperatures. A few weeks after an American sent over a specification but failed to carry it through. His means were ammonia. The idea is as we have stated, old enough, but he thought that by placing the freezing vessel above the level of the absorbing one, he should protect the apparatus from being injured by the vapour or steam thrown off by the ammoniacal gases. We cannot see how he could claim patent rights for that mere notion.

Mr. West improves machines by adopting the principle of liquefaction of ammonia by affinity under low pressure and its gasification by the removal of such pressure. It seems to aim at making better provision for keeping meat on board ship than to obtain a very wide application.

We intend to supplement this notice of ice making machines by an article on soda water making, wherein much excellent skill is required in the matter of machinery and management, and much chemical, and, for ordinary life, useful knowledge is associated.

THE THAMES STEAM FERRY

THE site obtained by the company for the operation of their ferry boats, and for their landing stages and warehouses, is directly over the Thames Tunnel, near the London and St. Katharine's Docks on the north side, and the Surrey Commercial Docks on the south. It is therefore well situated for acquiring the traffic between the docks and commercial establishments of the East-end,—Rotherhithe, Bermondsey, and Deptford. As no vessels of any kind are allowed to cast anchor or moor within a distance of the line of the Thames Tunnel, the Ferry obtains there a clearer passage than could be found at any other part of the Thames.

At present there are two boats similar in general construction, 82ft. in length and 42ft. in width, giving sufficient area for the accommodation of twelve two-horse vans, and having a carrying capacity of 50 tons, besides giving accommodation to a number of foot passengers. They are of iron, designed and built by Messrs. Edwards and Symes, of Cubitt Town, and engined by Messrs. Maudslay, Sons, and Field. The decks are the form shown by the illustration in *The Engineer* of the 22nd September, 1876. The engine-room skylights are placed between the horse tracks, and the two tunnels are placed one on each sponson; the deck is thus left clear for traffic. Rudders are provided at each end, and are controlled by the capstan from the top of either paddle-box. The two engines, of 30 nominal horse-power, are worked independently, so as to obtain complete control over the direction of the boat; and, if necessary, a complete revolution may be made within the boat's length, without the aid of the steering gear. The bulwarks at each end of the deck are hinged to be lowered like the tail-board of a huge wagon, and form a prow for the traffic to pass over between the boat and landing-stage, against which the boats will moor end on.

The level of the boats' deck at low water is about 24ft. below that of the river bank, and the nearest the boats can at such times of the tide approach the Wapping Wharf is 170ft., and that at Rotherhithe, 70ft. Inclined planes, such as those used at Liverpool, could not be employed to work the ferry at all states of the tide, so that it became necessary to mechanically transfer the passengers and vehicles to and from the boats. This has been effected by the hydraulic machinery designed by Mr. F. E. Duckham, and a large platform, which in its upper position, forms a continuation of the wharf roadway. The vehicles and foot passengers assemble on this platform until the ferry boat approaches to receive them; the platform is lowered by the hydraulic machinery until at a level with the boat's deck; its freight is exchanged for that brought across by the ferry boat, and the platform again raised to the road level. The platform measures 70ft. by 35ft., and weighs 80 tons; it is counterpoised by suitable ballast boxes. Horizontality during lowering or raising with the unequally distributed load is secured by eight iron columns, four on each side of the left, which act as guides, and support four horizontal hydraulic presses, which have a lifting power of fifty tons, and are connected at four points by chains with the lift platform. The chain from each press on the one side of the lift passes round a massive shaft fitted under and sustaining the platform, and having a corresponding connection with the corresponding press on the other side of the lift. As the platform moves the shaft rotates, and thus both sides of the lift are forced to work in unison. The two hydraulic presses on each side of the lift, placed horizontally one in front of the other, are coupled by stout connecting rods, so that one press cannot move without the other, and a horizontality is thus maintained in the direction of the platform's length. The effect of this combination is that each press assists or is assisted by others of the system, and that, although the loading may be most unequal, the work of the presses and the movement of the platform is correctly equalised.

Safety grips are being arranged to grip the guide columns on the instant of any irregularity of working of the suspending chains. The lift platform is itself a pontoon, and should all its attachment give way, would float with 100 tons of cargo.

The engines by which the hydraulic pressure is obtained are of 25-horse power. The accumulator is loaded to 720lb. per square inch. These, and the whole of the hydraulic machinery have been supplied by the East Ferry-road Engineering Works Company, of Millwall, under the supervision of Mr. H. Duckham.

The lift at Rotherhithe is close to the front of the wharf; but the long foreshore at Wapping rendered it necessary to provide a jetty 100ft. long to connect its lift with the shore. This jetty is formed in two spans of wrought iron single web girders, 5ft. 6in. deep, placed 19ft. 6in. apart for 60ft., and then splaying out to the same width as the lift platform. The joists are of wrought iron, the floor of oak. The lift platforms are of similar construction. The columns supporting the jetty and lift machinery are of cast iron 3ft. 6in. diameter, screwed about 15ft. into the ground and filled in with cement concrete. On the top of the main girders, about 3ft. above the level of the horse road, a railed pathway has been constructed for the convenience of foot passengers. At a distance of 60ft. beyond the river end of the lift, two columns 5ft. 6in. in diameter are fixed as dolphins to keep the boats in position while embarking and disembarking their freights. The girders were supplied by Messrs. Hawkes, Crawshay, and Company, Gateshead, and this portion of the work was carried out by Mr. John Gibson.

It is proposed to run the ferry once every quarter of an hour. The time recently occupied in transferring the Lord Mayor and suite from Rotherhithe to Wapping was from ten to twelve minutes, but under working conditions this, it is expected, may be reduced, so that the boats will be able to run. The crossing of the river traffic will make a difficulty.

In addition to the ferry proper, the company has considerable wharfage ground on each side of the river. That at Wapping has a total river frontage of 150ft., and covers an area of 12,500ft., irrespective of property on the opposite side of Wapping High-street. Substantial warehouses are being erected on the river side ground; these will be in three sections, of five floors and cellars each, and have a total floor area of 55,614ft. The centre section has been completed, and is already filled with merchandise.

The wharfing and foundations were constructed by Messrs. Henry Lee and Sons; the buildings are now being erected by Mr. J. M. Macey. All these works have been executed from designs by, and under the supervision of, Mr. A. R. Stenning, the company's architect. These warehouses will be fitted with hydraulic cranes, to lift from 20 cwt. to 30 cwt., all fitted with arrangements by which the quantity of water used varies in accordance with the work being done.

The proposed Tariff.

	s.	d.
Vehicle, 1-horse, empty 0s. 8d.; laden	1	6
Vehicle, 2-horse, empty, 1s. 0d.; laden	2	6
Vehicle, 3-horse, empty, 1s. 3d.; laden	3	6
Vehicle, 4-horse, empty, 1s. 9d.; laden	3	9
Pedestrian	0	1
Cattle	0	3
Saddle-horse and rider, or led horse and attendant ...	0	6
Barrow or truck	0	2
Donkey and cart	0	4
Cab, two or four wheels, with fare...	0	8
Cab, two or four wheels, returning empty	Free	
Carriage, two or four wheels	1	0
Every vehicle or machine propelled by means of steam or machinery, or by any other power than animal power, each wheel	2	6
Omnibus and servants, with one or two horses ...	1	0
Omnibus and servants, with four horses	1	6
Passengers, per head	0	1

With reference to the practical daily operation of the ferry, it may be admitted that experience has yet to be gained, and that practice will suggest the best means of working the traffic. It seems, however, that better arrangements must be made for thoroughly securing the "tailboard" of the boat to the floor of the lift, or otherwise accidents with horses will occur. Light hawsers, will not be sufficient to hold the ferry boats in a wind and tide-way, and on no account must unloading be allowed to commence until the "tailboard" is fully on the lift platform, secure there, and the position maintained by the continued working of the engines and by proper connecting arrangements. If the ferry traffic assumes anything like the proportions looked for by the company, difficulty will probably be found to attend the narrow approaches. These, however, are matters which may be overcome, and the practical utility of the undertaking, which has now been in hand three years, will be settled in a few weeks. With careful supervision it is probable that certain classes of traffic will find the ferry a means of avoiding the long journey to and from London Bridge, and the latter may be somewhat relieved thereby; that is, however, one of the most difficult problems in metropolitan management. It can only be determined by experience.

INDIA AND PAPER MATERIALS.

OUR notice of Dr. Hooker in last month's Magazine may be well supplemented by another of Dr. King's annual reports from Calcutta. No men in this or any other generation have done so much as Dr. Hooker and his father in the department of Eastern Botany, with a fixed design of giving and receiving as between the dependency and the mother country; and they have been favoured with successes which not only reward the expenditure of present labour but give sure tokens of future benefit to India and to England. We are supplying from Kew Gardens a want in a way that not only will make the wilderness a pleasant place, but will attract to it a more regular supply of the atmospheric moisture which plants require, in more regularity than the rough operations of nature will admit; and in so doing are also tending to assist the people in their ardent enterprise of avoiding droughts and famines.

Mr. Routledge of Sunderland, who is known as the benefactor of the paper trade in its depression by his labour and success in the discovery, culture, and merchandize of Spanish grass (Esparto) has supplemented that toil—now that the resources of Spain with its indigenous products are insufficient for the market supply of raw stuff—by the issue of a pamphlet in which he discourses on the qualities of the Indian bamboo and its suitability for the work of the paper-maker. Dr. King occupies an official position in Calcutta as director of the Royal Botanical Gardens there, and like Dr. Ridge has given much attention to the proposals of those who offer to utilize plants for manufacturing purposes. Our readers will have observed our reports from time to time describing the progressive method adopted and the successes which have ensued; they will have seen jute and gunny have "gone up" in the market because of their being acceptable in the manufacture of textile fabrics; and it is a curious condition of things and a wonderful ordinance of nature that while to India we are transporting trees and doing it good thereby, we seem to be able to use up what is really a waste supply of the native plants and trees. The supply may be precarious, as Dr. King cautions us to expect, but so was that of esparto when Mr. Routledge commenced his investigations and obtained his concession. The knowledge and experience he acquired in Spain are evidently guiding him in this analogous work in India. The wild grass ot the mountains of Hispania fed neither man or beast. It was a fibre and not a food. It was as worthless as some of the sand products of such sea-side places as those of Norfolk; but it happened to be abundant. There occurred great difficulties in obtaining sufficient concessions from the government to warrant the expenditure of capital, but those difficulties were surmounted; and there happened to be difficulties in the invention of machinery and the discovery of chemicals proper to the treatment of such unheard-of material; there happened also to be a still greater difficulty in the form of English prejudice, which enslaved the trade by an unbearable bondage to ancient methods and regular substances. Koop made paper out of straw in 1806 down at Bermondsey, but he was commercially smothered. Rag was the paper-maker's deity; and Mr. Routledge had to begin by selling his new material after all his toil—at about £4 a ton free on board. It has since seen three times the value, and now the supply is not equal to the demand. The merchant and chemist that in 1862 relieved the trade finds in 1877 that he must do it again, or the manufacture will be ruined. The raw material must be had at very low prices to compete with the foreign manufacturer, who, with his forests and his clay, can send in to our free market his paper made of wood and fine clay, duly weighted with the refuse of granite, but of quite sufficient quality for ordinary book or news work. We have rich grounds in India and a supply of cheap labour, which, if it gets a little more costly, no one will regret. If the enormous growths of bamboo, where it does grow, can be treated and reduced to "half-stuff" in the neighbourhood of East India Railways that lead to the coast, there is a field for the engineer, the chemist, the overseer, and the capitalist, of a consequence and proportion that will scarcely bear our most extravagant estimate.

Besides all this, another world is opening to the enterprise of such pioneers as Mr. Routledge in the newly made arrangements in Southern Africa; arrangements that will not end with the acquisition or federation of Transvaal, but must run through the entire region from the Nile to Elizabeth Town, wherein are fibres out of number, and beyond all yet realised, that will not only serve in the manufacture of paper but be obedient to the weaving machine.

Previous to describing Mr. Routledge's proposals, we will invert the order by giving Dr. King's ideas, reserving unto the end what observations seem to be required. In referring to the great expectations put forth, that in the young shoots of the bamboo there was a raw material which, by a simple treatment in its native country, could be transmitted to England in a rough dry state for paper manufacture, he says: It is essential to the success of Mr. Routledge's process that the bamboo shoots be quite young and succulent, and the great difficulty which at once presented itself to persons with any knowledge of the modes of growth of Indian bamboos was, that such shoots, being produced in moderate quantity from each clump, and only during a limited season of the year, the proposed paper stock-making machinery must, for a large part of the year, necessarily lie idle. To meet this difficulty, Mr. Routledge suggested that bamboo clumps might, by proper treatment, be induced, after most of their old stools had been cut away, to send up from the stools thus bared, regularly and irrespective of season, crops of succulent shoots suitable for conversion into paper stock. Mr. Routledge's expectations implied a very complete change of habit in the bamboo, for it is pretty well known that bamboo clumps, if entirely cut down, yield for several years but few and small succulent shoots, and, in fact, not unfrequently die. In order, however, to submit the proposed scheme to a trial under my own eye, six clumps of bamboos were cut down last year at the beginning of the rains (*i.e.* between the 10th and 20th June), when the buds of the young shoots of the season had completely formed and were nearly ready to burst through the soil. Soon after the cutting of the old stems, these buds developed into shoots, which grew with characteristic rapidity. These were allowed to grow until they began to show symptoms of becoming hard, and on 21st July they were all cut down. They were at once weighed, with the following result:—

Clump.	Number of young shoots.	Weight in pounds.
No. 1	11	166
No. 2	7	102
No. 3	6	78
No. 4	9	100
No. 5	5	42
No. 6	12	192
Total	50	680

This gives an average of 113 pounds of wet young shoots per clump. The time of cutting was the most favourable that could have been chosen, and the crop of shoots yielded was probably as good as it would have been had the clumps remained untouched by the knife. Judging from the size of the clumps, I calculate that at most 80 similar clumps could be grown on an acre of land. This allows an area of 576 superficial feet to each clump, and such close planting would probably necessitate manuring. Taking the yield of these six clumps as an average, and excluding all loss from death and accident, the yield on an acre during the first year of cutting would therefore be 9,066 pounds of fresh young shoots. It must not be forgotten that freshly cut bamboo shoots are extremely succulent, and that the amount for dry paper-stock that could be got from them would bear a very small proportion to their original weight. An additional difficulty that attends the scheme is that, since only fresh succulent shoots will answer, and these are of too high specific gravity to float, the cost of land carriage to the factory (a very heavy one in Bengal) would have to be incurred. The cut clumps above referred to were well cared for; leaf mould and tank soil were laid round them, and, as compared to similar clumps in the forest, they had the great advantage of immunity from fire, and from being grazed on by cattle. Since these young shoots were cut, a considerable number of woody twigs have arisen from the bases of the old stems. No fresh young root shoots have, however, appeared. Some such will, doubtless, appear at the usual time, which would be the beginning of the ensuing rainy season. These shoots shall be cut at the time recommended by Mr. Routledge, *i.e.*, when they are just beginning to become hard and woody, and with the cutting of these the crucial part of the experiment will begin, the results of which will be recorded in next annual report.

With regard to baobab fibre from the bark of *Adansonia digitata*, the young plantation, which it seems was made two years ago, is reported as progressing, but it is too young yet to afford any data as to the possibility of cultivating the baobab for the purpose of furnishing paper material with any satisfactory financial results. Dr. King gives it as his own opinion that a plant yielding an annual crop of fibre is, for economical reasons, more likely to answer than one from which a crop can be collected only at distant intervals. In this there seems a great deal of truth, and the dependence upon the bark of a tree for a

constant and abundant supply of paper material, more especially when the tree may be of slow growth, seems a very precarious source. The possibility is suggested that among the numerous graminaceæ and herbaceous urticaceæ, and malvaceæ, abounding in the reserves under the charge of the Forest Department of India, there must be some that would yield in sufficient quantity, and at a low enough cost, a fibre suitable for paper. It is hinted that amongst the wiry grasses so abundant on the Indian sea coast, several might be found to furnish as good a fibre for paper-making as the well-known Esparto grass.

And this hint is as worthy of recognition and submitting to practical tests as that about the "bamboo." Hungry places, sandy places, hot dry places yield vegetation exactly of the kind useful to the paper-maker, being all fibrous and juiceless. And seeing that the vegetable kingdom is absolutely universal—that there is not a soil, a place, or a stone on which it will not affix its stamp of royalty—these fibrous juiceless plants that have for countless ages lived and died, leaving only the heritage of their nature for a future unknown, and have been otherwise of no use to man or beast, will come to be of very great service in the ministration to the relief of those countless wants which an ever-growing population and an ever exigent manufacturing condition will require. And another aspect of this subject must not be forgotten. The grand remedy for social troubles and popular privation is to be found in commerce, and in production. Every statesman knows that; and almost every intelligent person understands it. If those poor abject creatures, who have nothing but "a caste" for a fortune, and that caste entails on them the most dire degradation of spirit and hope, can be enticed into profitable labour to which they have never been accustomed, the prejudices and superstitions which have hitherto been their task-master must relax their hold; if, instead of growing rice, and being a slave or worse, the poor creature can have a new occupation, neither conscience or priest can be offended at it; while the influence of a better condition will soon operate to his deliverance.

But Mr. Routledge having issued his proposals and described processes in detail, it will be necessary to furnish an epitome of these plans and the means selected.

Bamboo has an unequalled rapidity of growth. The specimen at Syon House attained a height of 60 feet in 12 weeks, and one at Chatsworth 40 feet in 40 days. Its applicability to paper-making is no novelty, but the cost has prevented its adoption, because of the long boiling and the quantity of caustic alkali and the enormous pressure required. Mr. Routledge has therefore by experiment ascertained that if the stems of the plant are cut down at an early stage—when it is a succulent vegetable, before the woody stage is reached, it yields to ordinary treatment like other fibrous tissues employed for paper production, and can be had in quantities manifold greater than any other plant.

It is therefore necessary that near the plantations there should be erected central factories for the manufacture of *paper stock* The stems (taken as dry) will yield by this process 60 per cent. of unbleached *fibrous paper stock*, baled up in merchantable condition, and it is stated that every acre would yield 6 tons—an enormous product as compared with any other fibrous material; and at a cost of £10 per acre to cover all charges.

Brought therefore to a central factory in this condition, the stems are passed through heavy crushing rolls, in order to split and flatten them, and at the same time crush, or smash, the knots, or nodes. The stems thus flattened, are then passed through a second series of rolls, which are channelled, or grooved, in order further to split, or partially divide them longitudinally into strips, or ribbons; these being cut transversely, into convenient lengths by a guillotine knife or shears, are delivered by a carrier, or automatic feeder, direct to the boiling pans, or elsewhere, as desired.

As the object of my process is to produce a fibrous or tow-like *stock*, retaining as far as possible the normal or natural condition of the fibre, and not "*half-stuff*" or "*pulp*," my system of treatment differs materially from the foregoing, more especially in the boiling and washing processes.

Both of these processes I conduct in a battery, or series of vessels (16, 20, or more in number), such vessels being connected together by pipes, or channels, furnished with valves, or cocks, so that communication between the individual vessels may be maintained, disconnected, and regulated as desired, in such a manner that the vessels, being methodically charged in succession with the material to be operated upon, the heated leys (composed of caustic alkali) can be progressively conducted from vessel to vessel of the series, passing over and through the material placed therein.

The leys are thus used again and again (each successive change, or charge of ley, carrying forward the extractive matters it has dissolved from the fibre with which it has been in contact) until exhausted or neutralized (when they are discharged), fresh leys being methodically and successively supplied, until, by degrees, the extractive matters combined with the fibrous matter have been rendered sufficiently soluble, hot water rinsing is applied until the residuary fibre is sufficiently cleansed.

By this system of boiling an economy of 30 to 40 per cent. of soda is effected as compared with ordinary processes of treatment.

When cleansed, a final cooling water is run on end through the fibre, drained, and then emptied into a railway waggon and conducted to a press. It is there submitted to the action of a devil which converts it into a towlike condition, and then dried by a current of heated air—fan-blast—and baled up for storage or transport, as with cotton or jute.

In this condition of "*paper-stock*," it may be kept an indefinite length of time without injury, and when received by the paper-manufacturer requires merely soaking down and bleaching, to fit it for making into paper, either by itself, or used as a blend with other materials, as desired.

The "plant" required would consist of a battery of boiling places, with necessary adjuncts and machinery, steam engines and boilers, sufficient to make 100 tons a week, or 60 tons of merchantable paper stock. Mr. Routledge considers the farm should be about 500 acres in extent.

There can be no doubt about the urgency of the matter. Esparto has more than doubled its original value, and now must be obtained chiefly from Algeria at enhanced charges for transit, and there is no other material that can be substituted for it in sufficient quantities and with due regularity. The trade is now feeling the same difficulty it suffered under in 1854 and in 1861, although since then the supply of rags has increased, and 150,000 tons of fibrous material imported annually.

In another part of this notice reference is made to wood, but the cost of production is a bar to its permanent position in the market or the factory. Straw continues to be used in increasing quantities. A "new material" is therefore much to be desired, on condition that in quality and cost it favourably compares with those now employed. The author adds some recommendations in reference to the use of megasse, the fibrous residue of the sugar cane after crushing, of which there are vast quantities now useless. These should be converted in the colonies, where labour is cheap, and the result be sent here, and on the Continent in the way technically known as *half-stuff*, or rather, as Mr. Routledge terms it, fibrous paper-stock. The final observation is:

"I believe with my new system of treatment 'bamboo' will prove to be as superior to 'esparto' in every respect, as 'esparto' was found to be superior to 'straw,' the only other '*raw material*' used when it was introduced.

"Bamboo' differs from 'megasse,' in as much as the latter is produced, as it were, involuntarily, its maximum value as a '*raw product*' being determined by its comparison with fuel; whereas 'bamboo' would have to be cultivated; but, as this plant will not only grow, but flourish, in localities unsuitable for other cultivation, and is produced with such extraordinary rapidity and abundance, it would appear that, as a *raw product*, it would not cost much, if any, more than 'megasse.'

"It is hardly my province to discuss here to which of the two materials, 'megasse' or 'bamboo,' the preference should be given. Suffice it to say that, with '*the admitted fact*' of the increasing scarcity of *raw material* for paper-making, there is ample scope for both. I have only to add that I shall be happy to advise with parties who may desire to interest themselves in either question, on addressing me at Ford Works, Sunderland."

In reply to Dr. King Mr. Routledge has written to the *Journal of the Society of Arts*:—

"I beg space to make a few remarks, inasmuch as it might be inferred, from the tenor of Dr. King's report, that the successful employment of bamboo for paper-making was dependent solely on the continuous growth, and the continuous cropping of the young stem or shoots.

"I will not attempt to discuss the botanical issues of the question with so eminent an authority as Dr. King, but will admit that the parent clump or stool may not bear cutting down in its entirety, also that the shoots are only produced once a year, and that during a limited season, until, indeed, we learn from Dr. King's next annual report the result of his further experiments confirming or modifying his present conclusions.

"Assuming, therefore, that the experiments now being conducted under Dr. King's direction should not be successful, it fortunately happens for the paper trade, and those, like myself, interested in extending the supply of suitable paper-making materials, that, practically, an inexhaustible extent of bamboo jungle exists in many districts in India, from which the stems can be collected in the regular season without having recourse

to any plantations, or to cutting down the whole young growth from one clump simultaneously, as I learn from excellent authority that if only, say, one-half of the season's growth of young shoots is cut, the stock is not injured, but rather improved thereby.

"My great difficulty hitherto, in communicating with the numerous authorities and correspondents in India, has been to explain what I meant by young stems and shoots, and to clearly define the proper stage of growth at which they should be cut, previous to their developing too prominent a woody character; and this difficulty still exists, as the growth of the stem necessarily is determined by the variety of the bamboo, the locality, soil, and climatic influence, &c., and as the character of the stem, and its suitability for the manufacture of 'paper stock' and paper, must, mainly be governed by these conditions, to lay down a hard and fast line would obviously be out of my power.

"Now, in discussing the laying out of a plantation (*vide* my pamphlet on the subject of 'Bamboo Cultivation,' page 8) I assumed, as a mere matter of calculation, 'that allowing the stems to be 2 feet apart, and only 12 feet high, 40 tons might be estimated as the yield per acre.' I am very much afraid that Dr. King's experiment in cutting has been conducted under some misapprehension in this direction, and that he assumed this growth of 12 feet only in height should not be exceeded, as in the tabular statement in the report 50 stems are shown to weigh 680 lbs. only, an average of 13·6 lbs. each, this giving not more probably than 10 feet of stem available for fibre, and that also too young and immature, as Dr. King speaks of 'wet' young shoots probably containing 80 to 85 per cent. of sap, being the result of only one month's growth, viz., 'starting from the 10th to the 20th June, and all cut down on the 21st July.' Had they been allowed to grow till near the termination of the rains, they would probably have attained a height of from 20 to 30 feet, most of which would have been available for fibre, and necessarily also have materially affected the tonnage per acre.

"In collecting, however, from the jungle or native forest, the yield per acre is hardly a question to be considered; proximity to a river or stream by means of which bamboos can be readily conveyed to a factory for manufacture into stock is the main point, and as I learn lately from British Burmah where these facilities exist, that stems of the season's growth can be laid down at Rangoon or Mouemlin at 15 rupees, say 30s., per mille, each mille nearly equal to the production of one ton of merchantable 'paper stock,' in this part of India, at least, plantations would not be needed, and I doubt not, under proper organisation, this cost might be further reduced."

ON THE PROTECTION FROM ATMOSPHERIC ACTION WHICH IS IMPARTED TO METALS BY A COATING OF CERTAIN OF THEIR OWN OXIDES RESPECTIVELY.[1]

By John Percy, M.D., F.R.S.

THERE appeared in the *Times* of March 6th, 1877, an announcement, in glowing language, of an alleged discovery by Professor Barff, by which iron might be effectually prevented from rusting, and, "however much exposed to weather, corrosive vapours, or liquids," might be rendered "practically indestructible and everlasting." The process consists in exposing iron to the action of superheated steam, whereby it acquires a tenaciously adherent coating of one of its own oxides, viz, magnetic oxide, which it is asserted protects the underlying metal not only from atmospheric oxidation, but also from that of corrosive re-agents. The fact that magnetic oxide would be formed under those conditions was known to every chemist, notwithstanding the statement of the writer of the article in the *Times*, that it was discovered by Professor Barff. That iron upon the surface of which a coating of magnetic oxide has been formed by the joint action of heat and atmospheric air is preserved in a greater or less degree from rusting, is a fact well known, I should suppose, to every member of the Institute before the announcement of Professor Barff's discovery; and, perhaps, the most striking example that can be adduced in proof of such protective action is afforded by a variety of Russian sheet iron. In a pamphlet which I published in 1871, I described the special character of this sheet iron, and communicated such information as I had been able to procure concerning its manufacture. The following is a quotation from that pamphlet:—"A particular kind of sheet iron is manufactured in Russia, which, so far as I know, has not been produced elsewhere. It is remarkable for its smooth, glossy surface, which is dark metallic grey, and not bluish grey, like that of common sheet iron. On bending it backwards and forwards with the fingers, no scale is separated, as is the case with sheet iron manufactured in the ordinary way by rolling; but on folding it closely, as though it were paper, and unfolding it, small scales are detached along the line of the fold . . . . . This sheet iron is in considerable demand in Russia for roofing, and in the United States, where it is largely used in the construction of stoves and for encasing locomotive engines." Now, from the circumstance of its being applied to the purposes just mentioned, especially roofing in such a climate as that of Russia, it may be inferred that it must be much less liable to rust than ordinary sheet iron; and of the correctness of that inference I have had personal experience. In 1846, I constructed, of this Russian sheet iron, a gas-combustion furnace for organic analysis, which I exhibited to the meeting of the British Association at Southampton in the same year. Ever since that period the furnace has been exposed to the atmosphere, sometimes to that of a laboratory, and yet it presents only here and there small spots of rust. Other specimens of similar sheet iron, which I have had in my possession for fifteen years and upwards remain free from rust, notwithstanding that they have also been freely exposed to the atmosphere. The metal used for the sheet iron in question is made from pig iron, either in a charcoal finery, or the puddling furnace: but, according to one account, only in the former. The pig iron is produced by smelting magnetite, spathic iron ore, and red and brown hematite, with charcoal and coal blast. For a detailed account of the process of manufacture, I must refer the members of the Institute to the pamphlet which I have mentioned; but there is one operation to which I invite their attention, and which is conducted as follows:—The rolled sheets are sheared to the dimensions of 28 in. by 56 in.; and each sheared sheet is brushed all over with a mixture of birch charcoal powder and water, and then dried. The sheets so coated, with a thin layer of charcoal powder, are arranged in packets, containing from 70 to 100 sheets each; and each packet is bound up in waste sheets, of which two are placed at the top, and two at the bottom. A single packet at a time is re-heated, with logs of wood 7 ft. long placed round it, and, for this purpose a furnace of particular construction is employed, which will be found fully described and illustrated in the pamphlet referred to, and a copy of which I herewith transmit. It consists of a re-heating chamber above, and a fire-place below, the two being separated by a floor, containing holes, through which the gaseous products of combustion from the fire-place pass into the upper chamber. The object, it is stated, of the logs of wood is to prevent, as far as possible, the presence of free oxygen in the re-heating chamber. The packet is thus slowly heated for five or six hours after which it is withdrawn and hammered. Now, during a considerable portion of this period, steam would continue to be evolved from the logs, and it becomes a question whether that steam may not be instrumental in forming a superficial coating of magnetic oxide of iron on the sheets of the packet, but it was not until I had read the account of Dr. Barff's process that this notion occurred to me. If it should prove to be well founded, then another would be added to the many remarkable instances in metallurgy of practices having been introduced, and long carried on, without even a suspicion of the scientific principles which they involve. Assuming the correctness of what has been asserted concerning the action of a coating of magnetic oxide of iron in preserving iron from rusting, it seems extremely probable that such action is due in great measure, if not wholly, to a peculiar physical state of the oxide. One condition is also essential, namely, the perfect continuity of the coating; for I have observed that when an article which had been coated by Professor Barff himself, and from which the oxide had been expressly removed in one or two places, was exposed to the joint action of air and water, especially salt water, rusting speedily took place at the denuded places, and proceeded with rapidity; but whether more rapidly than in the case of ordinary sheet iron, exposed to similar conditions, I cannot state, as no comparative experiments were made. This, however, is a point which will deserve particular attention. I trust that, in submitting the foregoing remarks to the meeting of the Institute, a desire to disparage Professor Barff's application will not be imputed to me. So far from having any such desire, I have pleasure in expressing my opinion that great credit is due to the professor, both for the originality of his proposal and for the manner in which he has experimentally investigated the subject. The next example which I have to submit to the Institute of the protection from atmospheric action afforded to a metal by a coating of its own oxide is copper, and it is a very striking one. For more than a century European metallurgists have been familiar with small thin bars of cast copper, of Japanese manufacture, which

[1] Iron and Steel Institute.

presents a beautiful rose-coloured tint, due to an extremely thin and pertinaciously adherent film of red oxide of copper, or cuprous oxide. This tint, according to my experience, is not in the least degree affected by free exposure of the bars to the atmosphere. I have had such bars in my possession for more than thirty years, and, although they have been freely exposed to the atmosphere during the whole of that period, yet they have not undergone the least change in appearance; they remain as bright and as beautifully coloured as they were when I received them. Now, as every one knows, when a piece of ordinary copper is exposed to the atmosphere it speedily acquires a dark-coloured tarnish. Hence the conclusion that there is some peculiarity on the surface of the Japanese copper which protects the underlying metal from atmospheric action; and that peculiarity, it may be demonstrated, is the presence of a film of cuprous oxide, in a particular physical state, which acts like varnish. The bars of Japanese copper are actually cast under water, the metal and the water, previously heated to a certain degree, being poured at a high temperature. I have fully described the process in a volume which I published in 1861, and I have recently obtained additional information on the subject from my friends, Messrs. Tookey and Godfrey, who have witnessed this singular process of casting in Japan. I have also succeeded in thus casting copper under water. It would be out of place, on the present occasion, to describe the process in detail. All that need be further stated is, that when copper is so cast, under suitable conditions of temperature, it acquires a coating of cuprous oxide, which acts in the manner described. The temperature is such that the so-called spheroidal action of water comes into play, and the metal flows tranquilly under the water. The superficial oxidation is probably due to the action of a film of steam, which there is reason to believe surrounds the copper under these conditions; and when copper is heated to a high temperature in steam, the latter, as shown by Regnault's experiments, is decomposed with the evolution of hydrogen and the formation of cuprous oxide. The last example of the action in question, which I shall mention, is afforded by lead. In the collection of the Museum of Practical Geology, in London, is a number of very thin sheets of lead, coated with bands of varied and extremely bright colours. Although the atmosphere has had free access to these sheets for about thirty years, the colours are as intense and as bright as they were at first. The sheets were prepared at Mr. Beaumont's smelting works, by dexterous skimming in the process of desilverising lead by Pattinson's most original and beautiful process, and were presented to the museum by Mr. Sopwith, at that time general manager of Mr. Beaumont's mining and smelting establishments. The colours are certainly caused by excessively thin films of oxide lead of various thicknesses.

AUTOGRAPHY.

AUTOGRAPHY is a process by which manuscript of drawings, made on common paper by the agency of a special ink may be transferred to a lithographic stone and then printed.

The process has been long known, but a new method, both simple and cheap, has been propounded by Professor G. O. Sars, of the University of Norway, in the *American Journal of Science and Arts.*

The drawing is made on common letter paper, which has been coated on one side with a thin film of starch by means of a sponge; on this ground the drawing is done. As the effect of the shading is liable to suffer if the paper be too glossy, the Professor recommends giving it a granulated surface by pressing it against a lithographic stone. By using stones with more or less smooth surface for this purpose the paper can be made to possess any surface smoothness that may be required for the purpose of the drawing. The paper is next fastened to a sketching board or a piece of paste board, and the drawing effected by the use of the lithographic crayon.

The paper must be cut to the size intended for a full plate, and the drawings arranged in the same order as they will have to appear in the printed plate, just as in common drawing with lead pencil or rather crayon. The figures should be first sketched in outline on common paper, and then transferred to the prepared paper in the usual manner by means of transparent paper and plumbago paper, blue paper, or, still better, red; the transferring being done with a lead pencil of moderate softness. The details of the figures, the shading and finer structural conditions, may be drawn off-hand with the crayon on the prepared paper, after the outline has been transferred. Any correction or change in the drawimg can easily be done by erasing with a fine scalpel, taking care only that the starch film be not injured. When the plate is finished to the satisfaction of the worker, it is transferred to a common smooth lithographic stone, in the following simple way:—the back of the paper is moistened with water containing a small portion of nitric acid: and after having been put for some time between moistened soft printing paper, the plate is laid face downwards on the stone, which is then put into the press for a moment. To make more sure of it the outside of the paper may be slightly rubbed with the finger: if then the paper be stripped off the drawing and the entire film of the starch will remain on the stone, and the figures of course reversed. Then treat the stone in the common way with gum arabic and a weak etching, and it will be ready for printing. The entire process of transfering from the paper to the stone is simple but requires great care and much practice to be successful. It would perhaps be better to leave that to the charge of a professional lithographer. It is an excellent method for preparing amateur students' plates at an insignificant cost and of complete efficiency.

PAVEMENT OF ROADS IN CITIES.

LONDON is not alone in demanding improvement in the paving of its streets, and no amount of Conservative protest will avail to interrupt a universal reform. The proper Conservatism is like the National, a progressive advance by well attested and assured stages: it is not possible to revive the ancient cumbrous ways. Try and imagine a return to the old days when the Strand in London was paved with flint stones—great boulders—and when the streets of Westminster had all the sewage running down the middle of the street, and each side slanting like an inverted roof, when there existed no other protection for the foot passenger than a series of posts, sometimes connected by chains, and sometimes not. Yet all this is not much over a century ago a fair description of London and Westminster. Here a light, and there none at all.

Observations concerning the method of paving have been publicly made, that, without controversy—for controversy is not our duty—ought to be supplemented by some practical suggestions and recital of facts. Had the traffic of our large cities been kept to the old limit, the occasion for change would in all probability never have arisen; but when that traffic makes the provincial towns of England and Scotland very much more noisy than was London forty years ago, a stage has been reached demanding immediate remedies. Human nerves are very elastic, and submit to considerable tension, but they give way. Perpetual noise is nothing less than paralysis. We cannot bear it. The man must get away or he will lose his faculties, or wear out all his energies. Hence the demand for change.

In the time of the late French Empire there grew an almost universal desire to see Paris. The home of fashion and elegance had ever possessed her royal honours among the cultured and rich, and there was nothing surprising that, as culture and wealth became diffused, taste should also take the same preferences as had always been the attendant among those who enjoyed hereditary claims. Now it happened that the Emperor determined to improve Parisian architecture and the municipal arrangements, in order to extend the fame of the French metropolis, to further the interests of the citizens, and to enhance the comfort of the home and foreign visitors. Paris had worse pavements than London: it was far behind us in its sanitary arrangements on public highways. The Emperor attacked the plague spot, and availed himself of all the practical scientific skill he could invite, to compete in the invention or adaptation of some novel material for the improvement of the ordinary streets. Many experiments followed, and England watched them. Every visitor to Paris returned with wonderful tales about the changes conducive to comfort and adornment which were proceeding, and ultimately the Corporation of London put itself into communication with the authorities in Paris, in order to ascertain what could be done to relieve London from the incessant din of vehicular traffic, which had begun to obstruct the ordinary commerce of the city. Paris had begun its work in 1854, and therefore by 1870 could offer the counsel of experience. Many preparations of the asphalte type had been tested, but that known as the Val de Travers Asphalte, which is composed of a mineral from the Val de Travers, near Neufchatel in Switzerland, is the most valuable for forming a road. It had been extensively used in Paris since 1854, and in 1869 485 square yards were covered with it in Threadneedle Street, on a foundation of concrete cement, eight inches in thickness. Then followed a piece in the Poultry at the inclusive cost of 18s. a

square yard. The advantage in places of intense commercial life needed no assertion. In 1871 Old and New Broad Streets, Throgmorton Street, Queen Street, Gracechurch Street, the Old Bailey, Milk Street, Russia-row were covered with 16,000 square yards, and another 9,000 remained on contract.

Then came the Limner, extracted from a mine at Limner near Hanover, in Brunswick; and Lombard Street provided the company's first city contract. Moregate Street followed, and the two qualities had a fair competition with an extra rival in Barnett's liquid iron.

Asphalte is made either of natural or artificial asphalte with pulverized iron ore, or sesquioxide of iron mixed with a little tar.

London was tested in Great Carter Street by Mr. Dounell's patent adamantean concrete, composed of blocks made of broken stone, chalk lime, and clay, mixed with vegetable or mineral tar. This mixture cost 20s. a square yard.

An attempt to combine granite and asphalte failed, and the question of cost had to be entered on, seeing that the silent highway had won the attentions of the city. The result of that examination showed the difference to be immaterial, and therefore in regard to convenience, safety, cleansing, construction, repairs, and durability, lay all the elements of a just conclusion. Wheels run over asphalte, said the London surveyor, as on a tramway: he adds that M. Léon Malo, a French engineer, computed the saving in wear and tear of horses and carriages in Paris, if the method obtained universal application, would be £340,000 a year. Water cannot get through it, and that has always been a serious difficulty in granite roads, the subsoil of which became black in a very short time from the percolation of noxious liquids, and in hot weather impregnated the atmosphere with injurious vapour.

Nevertheless, whatever excellence could be claimed for asphalte in the way of cleanliness, safety, and silence, it did not prove equal to the requirements of steep streets. There was not sufficient grip for the horses' feet; and in frosty weather would be impassable without being sanded or gravelled: and therefore in the following year the Commissioners of Sewers permitted the application of another principle, and the first test occurred in Bartholomew-lane. It had worked well in America, St. Petersburg, Vienna, and Paris. The substance is wood, and its pretensions were—absence of slip, noiselessness, elasticity,—durability, and an even surface at all times. The construction varies according to circumstances, that is to say, the nature of the traffic and the gradient required. The first experiment had a bed of sand of sufficient depth to form a good grade, say 1 or 2 inches; on that a flooring was placed which consisted of two thicknesses, one laid horizontally, the other transversely, each thickness consisting of a ¾ in. deal, pickled in tar. Upon these boards, blocks of wood measuring 9 × 3 × 5 inches are placed, and between each row of blocks, a strip of wood 1 × ¾ inches is nailed to the flooring. These are intended to steady the blocks in their places during construction. After thus being laid, the spaces or joints are filled with hot gravel, upon which hot tar or pitch is poured. This is rammed tight home, and again repeated until the spaces are filled up. Subsequently another application of tar is made over the surface, on which a dressing of fine gravel is thrown. When this is dry, the pavement is complete.

This method has had great favour. Just after the demonstration of its success, London Bridge incline by King William's statue was laid with it, and after more than four years appears to be as good as ever. Now Fleet Street, another sharp incline, is covered thereby, and the opinion of the best official judges is decidedly in its favour for all streets that are not on a level.

And it must be clearly borne in mind that every system had a fair trial. There were four kinds of asphalte pavement, viz.—The Trinidad Asphalte, Bitumen, and Oil Company, the British Asphalte Company, the Sociétæs Francais des Asphaltes, and the Montrotier Asphalte, and Cement Paving Company. These experiments were made at the city expense, and therefore the experience derivable from those operations is the best that provincial cities and towns can obtain. Of course, they were all accused of being more slippery than granite or than macadam, and therefore more injurious to horses. We need not say that such allegations are unjust. Captain Shaw, the director of our Fire Brigade, has plenty of opportunities of knowing what ground fast conveyances of great strain can get over best; he drives as fast as horses can go, and apparently, because of his function, almost recklessly, and his evidence against granite is conclusive. But we have nothing to do with commercial rivalries. It is enough that the cruel macadam is abolished to the extent it is: even with the steam roller it would not, and does not do, because it is perpetually under repair from its liability to form holes, however solidly it is put down. It is less noisy than granite, but the inequality of surface is a great objection, and insurmountable even with the noisy interference of the steam roller.

The modern pavements have this excellence in common they all reduce the roar of the crowded streets to comparative silence, so that conversation is possible, and business can be transacted in places where the human voice had previously struggled in vain against the incessant surrounding din. As has been well observed in this respect the wood is preferable to asphalte: a gentle hum is all that is heard, and that is caused by the slight grip it provides, whereas in asphalte wheels slide noiselessly, but the clatter of the iron shoes of the horse make a disagreeable noise.

The reform wrought in London will spread over the whole country. Property in districts or valuable houses situated in thoroughfares connected with railway stations or squares has been considerably enhanced in value. Instance the western side of Bloomsbury Square or that of Cavendish Square: the one wood, the other asphalte: one who should revisit those localities would feel instinctively the relief, and would scarcely feel that he was again upon familiar ground.

The whole question depends upon comfort, and so we end as we began. The cost is as nothing when public comfort is the end to be attained, and hence it is surprising that scientific gentlemen should cling to the ancient methods when it is so manifest that there has been discovered a more excellent way.

PHOTOGRAPHIC PAINTING.

BACKGROUND is the most serious item in the artistic management of photography. You must keep the picture well together—and that is a very fine idea for a good photographist to realise. An art that simply aims at the representation of nature ought not to need the aid of artifice. But tone you must have in the background, and it makes a great difference in the treatment of a face. For miniatures a great variety of backgrounds are used, from maroon to cool grey or green. A good, generally useful, mixture for a miniature is a grey composed of French ultramarine and sepia, with gum, shaded off to deep brown or pure sepia at the lower corners over the shoulders, or even a little burnt sienna. If a maroon be desired, sepia and lake should be used for the light parts, with Vandyke and lake for the deeper parts. A pretty effect is got by washing in with two colours and stippling with a third; for instance, washing in with burnt sienna and ivory black, and stippling with Prussian blue. A greenish background may be got with emerald green and a little black, or French ultramarine. As a rule the light part of the background should be cool and the deeper parts warm.

The background should be washed in as evenly as possible and then stippled up, or, it may be, evened up by a little stippling, and then cross-hatched. I do not think it well, nor is it usual, to introduce objects into backgrounds of small pictures; but anything over (say) 10 × 8 may have a place, if really desirable and of any use. A panel or corner of a room may be introduced. If the former, do not let it be too hard or distinct, nor painfully and distinctly made out through its entire length; if the latter (a corner), remember the way the light comes. Also note that the corner of a room—the extreme corner—is never dark; for if you look at that part of a room you will find there is a line of light running down it—probably reflected light—from the two sides. A curtain is a favourite device; but how rarely do you see it well done! It should not be too straight, and any corners should be so arranged as not to repeat the outlines of the figure. But wherever there is a prominence in the figure one should be opposed to it in the curtain; and yet this must not be done too mechanically or obviously. As to colour, if you want to force a pale complexion, of course green is the thing; or, on the contrary, if you wish to cool a red one, oppose a red curtain to it.

There is another rule recognised by most artists, and that is that if there be a small piece of very bright colour anywhere in a picture there should be something introduced somewhere to "repeat it," as it is called—generally in a slightly lower key of colour. The latter is sometimes of use in another way. Suppose you are obliged—as sometimes happens, especially in portraits—to introduce something objectionable in colour, either from its being in a wrong place from a pictorial point of view, or from its being too bright and staring, you may paint it rather quieter than you otherwise would, if you repeat the same colour somewhere else much lower in tone. It makes the other look brighter, without its being so obtrusive.

In painting vignettes, neutral tint with a dash of Indian yellow makes a pretty colour for the background, the form of which is of the greatest importance. It should partake of a cloudy character; but the same rule applies as in a curtain—it must not repeat the outline of the figure, nor must it be a plain oval, as if the figure were sitting in an egg. It must be broken up into a jagged edge—not a repetition of the same curve over and over again, all round, but some of the points round and some square in character, and of different sizes. It should be finished off with a soft, broad cross-hatch. There is a great art also in finishing off the drapery of a vignette. The lines and shadows should be sketchily prolonged, and that part of the body coming next after the vignetting dimly suggested with a few dashing strokes of the brush. There is much greater facility for getting a nice, sketchy effect on plain salted than on albumenised paper, and that has led some artists to take an albumenised print of the head, cutting it carefully out, rather within than outside of the hair, pairing the edges into a bevel at the back, and gluing it on to a piece of plain paper or drawing-paper sufficiently large to admit of a body or part of a body being sketched to it. A landscape or panelled background can also be easily introduced by a good draughtsman, and the effect is really very charming. Of course it can be done on any tint of paper. Bits of ivory are also let in with photographs of the head and hands on a similar principle; only the ivory is so thick that a hole of exactly the same size and shape has to be cut and the ivory let in.

There are two distinct methods of painting on a photograph in oil, answering somewhat to tinting and highly finishing in water colour. One is by doing as much as possible with glazes of colour largely diluted with medium; and the other is like the ordinary painting in oil, the effect being very similar. If an autotype be used you may commence on it at once, and the colours will bear out on it most brilliantly, and not sink in the least—no small advantage. The mess and trouble of sizing an albumenised silver print is often very annoying, and proves a great waste of time; but it is absolutely necessary. A hot, thin solution of Nelson's gelatine with a little powdered alum is good.

RHEEA FIBRE.*

IN 1870 the Government of India offered a prize of £5,000 to the inventor of the best machine or process for the preparation of the fibre of the *Böhmeria nivea* (popularly known under the names of Rheea, Ramie, and China grass), and the terms on which machines would be admitted to competition were widely notified in India, in Europe, and in America. Many persons declared their intention to compete, but ultimately only one machine was actually brought to the place of trial. The machine having been carefully tested at Saháranpur in the autumn of 1872, was found imperfect in some important respects, and the inventor was adjudged not entitled to the full reward. He was, however, presented with £1,500 in consideration of the partial measure of success he had attained after great perseverance.

2. This machine has not since been adapted by the inventor to practical use, and no improved process of preparing the fibre of the rheea has been yet discovered by other persons. Meanwhile the demand for rheea continues, and the conditions which induced the Government of India in 1870 to offer a prize remain substantially unchanged.

3. His Honour the President in Council, therefore, considers that it is desirable to renew the offer, and it is accordingly hereby notified that a reward of fifty thousand rupees will be paid to the inventor of the best machine or process which will separate the bark and fibre from the stem, and the fibre from the bark, of the *Böhmeria nivea*.

4. A smaller reward, not exceeding ten thousand rupees, will be given to the inventor of the next best machine or process, provided it is adjudged to possess merit, and to be capable without difficulty of adaptation to practical use.

5. What is required is a machine or process capable of producing, by animal, water, or steam power, a ton of dressed fibre of a quality which shall average in value not less than £45 per ton in the English market, at a total cost, including all processes of preparation and all needful allowance for wear and tear, of not more than £15 per ton, laid down at any port of shipment in India, and £30 in England, after payment of all the charges usual in trade before goods reach the hands of the manufacturer. The processes of preparation are to be understood to include all the operations required subsequent to the cutting of the stems from the plants in the field, until the fibre is in a condition fit to be packed for conveyance to the market.

6. The machinery employed must be simple, strong, durable, and inexpensive, and should be suited for erection in the plantations where the rheea is grown. It must be adapted for treatment of the fresh stems, as cut from the plant. The treatment of dried stems offers certain difficulties, and the fibre prepared from them must, moreover, always be much more costly than the fibre produced from green stems. Except during the hot dry weather preceding the rains in Upper India (where rheea grows best), it is very difficult so to dry the stems that no fermentation or mildew shall occur. But during this season the stems are comparatively short, and the crop poor and stunted, unless it is artificially irrigated, and such irrigation greatly increases the cost of cultivation. In the rainy season the plant is in fine condition, but at this season it is almost impossible to dry the stems in quantity without injuring the fibre, unless recourse is had to artificial means of desiccation, which greatly increases the cost of the material. It is, therefore, obvious that the attention of inventors should be given to the discovery of a process for the treatment of the green stems.

7. The trials will be held at Saháranpur, in the North-Western Provinces, in the months of August and September, 1879. Machines entered for competition should be placed *in situ* and be ready for work not later than the 15th August, the competition commencing on the next day. The judges will be appointed by the Government, and they will watch the whole of the trials. But the machines shall be worked and adjusted by the competitors themselves, and no person shall touch a machine without the consent of the inventor.

8. The Government of India will provide proper shelter and accommodation at Saháranpur for all the competing machines as well as the motive power required. It will also pay for the transport from the sea-coast to Saháranpur of all machines up to the limit of one ton each, the freight on any excess weight to be defrayed by the owners. The present rate of freight by rail from Calcutta to Saháranpur is Rs. 3·10 per maund, or Rs. 98·11 per ton, and from Bombay to Saháranpur Rs. 4·1 per maund, or Rs. 110·9 per ton. A free second-class ticket to Saháranpur will also be given to any person in charge of a machine.

9. The owner or owners of the successful machine or machines shall not be entitled to receive the reward offered, except on the following conditions, viz:—

(1.) That a complete technical description of the machine, illustrated by plans drawn to scale, shall be prepared and published (Government paying the cost) for the information of the public.

(2.) That after the expiry of three years from the date on which the award is made, the public shall have the right of manufacturing similar machines, on payment to the owner of a royalty of 10 per cent. on the cost of each machine so manufactured.

10. All persons desiring to compete, under the terms and on the conditions specified above, are requested to make known their intention not later than the 31st December, 1878, giving the following particulars:—

1. Name in full, and residence.
2. Profession or occupation.
3. Number of different kinds of machines entered for competition.
4. Brief description of each machine.

Intending competitors will, at the same time, declare themselves bound under penalty of disqualification of the competing machines and forfeiture of all claim to the Government reward) to conform to all rules which may be prescribed by Government in connection with the conduct of the trials, where applications should be addressed through the India Office.

* Notification issued by the Government of India, Department of Revenue, Agriculture, and Commerce.—Fibres and Silk.—Dated Simla, the 31st August, 1877, No. 45.

ARTIFICIAL ICE.

WE have in another article shown the best method known in England, and the reader will understand that there are several processes for producing artificial ice at a cheap rate, but few if any of them are capable of yielding a product as transparent as good lake ice. M.M. Turretini and Pictet, of Geneva, who have devoted much time and attention to the subject of ice-making, have recently patented a method of insuring the transparency of the artificial ice. This transparence can only be obtained by freeing the water from the air which it con-

tains, and which is retained when congelation takes place. Attempts have been made to attain this result by agitating the water in the moulds during the congelation, by means of a mechanical agitator, or by circulation; but this operation is hardly practicable for application on a large scale, and requires costly and complicated apparatus. In the process devised by the patentees the water intended for filling the moulds is introduced, in the first place, into a cylindrical vessel by means of a pipe terminating in a funnel, and provided with a stop-cock, so that the cylinder can be closed air tight. It is filled nearly to the top; in the interior of the cylinder an agitator carrying beaters is arranged; its axis passes through a stuffing box, and it can be rotated by means of a pulley and band. The bottom of the cylinder also carries fixed beaters or pallets interposed between those of the agitator. At the top of the cylinder there is a pipe in communication with an air-pump, which draws the air from the cylinder, and maintains a vacuum within it. Another pipe passes out from the bottom of the cylinder, and is provided with a stop-cock for drawing off the water, when it has been purged of air, to the moulds in which it is to be frozen. By these means air can be separated from water on a large scale at a very small expense. Another very simple and efficacious process may be preferred to the above method. This process consists in aiding the escape of the air from the water by passing a current of air or of a suitable gas through the water intended to be frozen. This may be done by plunging into the moulds a pipe connected at the top with a blowing machine. The air issuing from the end of the pipe at the bottom of the mould sweeps away as it rises all the air contained in the aqueous mass, which is liberated at the instant of congelation, and there results a perfectly transparent block of ice. The patentees do not state any claim, nor do they supply any drawings of machinery adapted for the purposes of their invention.

MANGANESE BRONZE.

MR. PARSONS appears to be making a great success in the introduction of this production, and every test applied thereto only increases its fame and establishes merit. No longer confined to the domain of plausible theories which may gratify or may disappoint their believers, the success of the testing operations has resulted in setting up manufacture, not only for castings, which was its primary destiny, but in the production of rolled rods for bolts, and other rods used in pumps and the like, and a still further extension not only of utility but excellence. He is now engaged in manufacturing sheets and sheathing wire and tubes. At the Royal Gun Factories, a series of experiments have been made with the object of ascertaining the tensile strength of manganese bronze bolt rod in comparison with the ordinary muntz or yellow metal, and these are the results:—

Experiments made at the Royal Gun Factories on the Comparative Tensile Strength of Parsons' Manganese Bronz Muntz Metal and Gun-metal, September 11th, 1877. Diameter of specimens, ·533in. Length of breaking part, 2in.

No.	Material.	Strain per sq. inch.		Ultimate elongation in 2in.
		Elastic limit.	Breaking strength.	
	Parsons' manganese bronze bolt rod:	Tons.	Tons.	Per cent.
1	Cold Rolled	34·4	39·6	11·6
2	Forged and annealed	16·6	30·7	20·7
3	Hot rolled and annealed	15·2	27·4*	12·8*
4	Cold rolled and annealed... ...	14·5	29·1	18 3
5	Hot rolled, milder quality ...	11·0	29·0	45·0
	Muntz metal:			
6	Rolled and annealed	7·8	24·0	54·6
7	Gun-metal, cast	7·0	16·0	16·6

The higher qualities of the manganese bronze, numbered 1, 2 3, and 4, are intended principally for engineers' uses—such as bolts and nuts, screws, pump and other rods, forgings, &c., which for various reasons require to be of some metal other than iron or steel, and for which hitherto either Muntz metal, brass, or gun metal have been employed, the superiority of the manganese bronze over which, the results above tabulated clearly show, it being fully twice as strong as either Muntz metal or gun metal. The strength of the cold rolled specimen, No. 1, is very remarkable, this material sustaining a strain of 34 tons before stretching, with an ultimate strength of nearly 40 tons per square inch, and an elongation of 11·6 per cent. of its length places it on a level, and, in respect of its elastic limit, above the best steel used for constructive purposes. This quality should prove very useful for pump and other rods, spindles and axles, screws, and other articles that can be made from the rolled rod without reheating it, as it possesses an amount of transverse strength and stiffness commensurate with its great tensile strength. The milder quality, No. 5, will, it is believed, prove valuable for ships' bolts, and such like purposes, it being about 50 per cent. stronger than Muntz metal, and at the same time sufficiently ductile to be rivetted cold, although it, and all the other specimens, can be worked at a red heat if required.

We have stated above that this manganese bronze has also been tested for the manufacture of sheets and plates, for wire and tubes, and the operation is stated to be most successful. In these cases it is as greatly superior to brass as the rolling rod, being quite twice as hard and strong, while at the same time, of equal malleability and ductility.

The inventor declares that he has ascertained that the greatest heat it is likely to be exposed to in a locomotive or high-pressure boiler does not in the least injure by reducing its strength, toughness, or hardness; and he does not see why it should be otherwise than eminently suitable for boiler and condenser tubes: and that it is likely to prove greatly superior to copper for fire boxes, because being so much stronger, a less thickness can be used, and of course a great reduction in cost is secured.

*This specimen was not broken through the shank, but gave way prematurely at the base of the thread where the head was screwed on, owing to its having been nicked by the turning tool.

MODERN MECHANICAL PROGRESS.

"NOT proceeded with" are words of well-known significance, but not very consoling. During the last few weeks an extra freight of this kind of fruit—if fruit it can be called—has come to market, and, for the most part, it consists of contrivances more properly appertaining to domestic rather than constructive or scientific associations. One desires to teach us the art of peeling potatoes by machinery, but has not proceeded therewith because, no doubt, some good friend has been honest enough to assure him of what is familiar to almost all, that the potato is spoiled by skinning or peeling. Another contrivance for lawn tennis also failed, because it consisted of a mere india-rubber ball covered with felt, and therefore hardly within the lines of patent law. Another would make millboard and pasteboard in endless webs, but the idea is not new. Pulp passing to an endless wire mesh band, and then subjected to vacuum to be passed between pressure rollers, is very near as old as Dickenson's machine. Then, to show how inventors avail themselves of current fashions, one would meet the objection to locomotives on common roads by a contrivance to deceive horses by means of a mechanical horse with moving legs, &c., and accompanying sounds like the clatter of hoofs, which really appears almost ridiculous. But of doubtful schemes, here is one concerning pavements, whereby cast iron blocks are formed, with dovetail groove across below to engage a corresponding wooden block, also studs on one side to regulate the intervals, also longitudinal grooves on the face, filled with concrete or grouting. And another to obtain a trotting motion in velocipedes, in which the seat performs the same functions as a treadle, being hinged, say, at the back to a curved C piece, while at the fore part is a shaft (with vertical axle passing through the seat), having each end connected by rods with cranks on the driving wheel; the up and down motion of the body drives the bicycle. To aid in passing the dead points, another crank is provided, from which a rod passes upwards through a ring on the guide rod of the seat; this rod can be moved with the hands to give half a turn to the driving wheel. Fixed side pieces are provided to represent the side flanks of the horse, and others to act as stirrups. An enthusiastic gentleman patents a singular arrangement in tobacco pipes, that provides for the smoke to pass up through two inclined holes in the bowl, then down a vertical hole into the stem (the top of the vertical hole may be closed by a stopper or permanently); the opening in the stem at the inner end of the mouthpiece is enlarged below to form a reservoir for the saliva.

These are but samples of many, but the majority of communications are really contributions to perfection, or almost novelties. In the absorbing field of tramway and other locomotive engines, Mr. Hughes—so well qualified and entitled to be a rival, patents an improvement in detail that is worthy of note,

629. By it the supply of steam to the cylinder valves is controlled by means of a slide valve under the steam dome, operated by a rack, and a toothed segment or horizontal shaft. A steam brake has a rod extending up from one of its links, and the end of this when the brake is applied acts on a tappet, so as to rotate the horizontal shaft and move the valve to its closed position. Speed is indicated by motion of mercury in a tube connected with a vessel, in which the liquid is influenced by a diaphragm acted on by a rod, which partakes of the motion of the governor. The outlet valve (for condensation water) is connected by links, rods, &c., with the horizontal shaft, so that it is closed when the stop valve of the steam pipe is in its neutral position.

And for heating railway carriages by steam, Mr. Clark, 2226, completes his legal position by a contrivance thus described :—

This relates to combination of (parallel) pipes with a main pipe, so that the supply of steam is regulated by a stop-cock worked from within the carriage; an automatic coupling for pipes, in which a spring catch on one part of the coupling engages with a cam or section of a screw thread on the other, and the one part is then turned on the other (in releasing, the catch is tapped by a chain or cord); a check valve in each of the adjacent parts of the coupling becoming inserted, for passage of steam, when the coupling is united; a steam trap, consisting of an iron cylinder with expansion tube of brass projecting horizontally from its head, with rods and levers to work valves, one at the outer end of the tube, the other at the head of the cylinder. Springs are interposed between the levers and the valves.

MANUFACTURE AND USES OF BIRD LIME IN JAPAN.

THE following extract, which is taken from the *Hiogo News*, is inserted by Consul Annesley, in his report upon the trade of Hiogo and Osaka. Although bird-lime may be obtained in small quantities in other countries, still Japan may perhaps be considered the only country in the world in which it is regularly manufactured on a large scale, and as an article of some commercial importance, the production of which gives employment to some thousands of people.

The Chinese characters used to express the words "mochi," sometimes called "tori-mochi," to distinguish it from "mochi" (rice-cake), give an excellent idea of the nature of the article, and may be freely translated "bird-catching, sticky substance." It was first manufactured at a place called Yoshino, in the province of Yamato, and the manufacture has spread thence over the whole of Southern Japan, being limited in the locality by the habitat of the trees from which the article is made. The date of its discovery it is certainly difficult, and perhaps altogether impossible, to obtain, some placing it 500 years back, and some only 300. It is, however, certain that within the last twenty years, the quantity that has been brought into the market has been perceptibly affected through the destruction of the trees, by denuding them of their bark for its manufacture. The Japanese have made some attempts to arrest this destruction by leaving, in a particular manner, a certain amount of the bark on the trees, with the hope that they might serve a second time; but it is found that the article made from this second bark is of very inferior quality.

Osaka is the great centre of the mochi trade; large stocks of it may be found, anomalously enough, in the hands of the Kane-Cutsaya (dried fruit merchants), who have their head-quarters in and about Tema. Its present value is about 13 yen to 16 yen per picul (133⅓ lbs.). The best kinds, which are distinguished by being free from bark, of a dull whitish colour, extremely viscid, and having a very gummy consistency, come from the provinces of Yamato, Kischin, Tosa, Aiva, and Igo, an inferior quality being made in Satsuma, Choshin, Bungo, Isé, and Mino, the two latter places being the northern limit of its manufacture. All found north of these provinces is imported from Osaka and places south of that port. The best kinds are said to keep good for any length of time. The principal tree from which this bird-lime is made is a dark evergreen, having its habitat in the southern half of Japan; it grows high up the shady sides of deep mountain glens, and is frequently used by the Japanese as an ornamental shrub; in fact it may be seen in the ornamental grounds of the Osaka Railway Station. Its bark is of a greyish brown colour, and roughish texture; the leaves are opposite, smooth, dark green, rather more pulpy than the English holly leaf, ovate-acuminate in form, have an unbroken linear-edge, a very short petiole, and almost imperceptible stipules. Its efflorescence is a panicle, centripetal in its development, having small, white wax-like diandrous and monopetalous florets, which are also slightly cruciform.

The manufacture of bird-lime extends over a period of several months, commencing about June, when the bark of the mochi trees is stripped off and macerated in water for about forty days, after which it is collected and beaten in a mortar, exactly in the same manner in which rice is cleaned. The pestle, however, is of a different make, being shod with iron, the flat under surface of which is armed with spikes projecting downwards. When the pulpy mass under the pestle becomes glutinous, it is taken out and washed in water. This is done to remove as much as possible of the rough outer bark, and the pulp is then again pounded and treated in a cauldron with hot water, on the surface of which it floats. During this treatment it undergoes continual manipulation at the hands of the workman, for the purpose of disengaging the remaining particles of bark, which sink to the bottom of the boiler. This is the most difficult part of the process, as considerable skill and experience are required in the workman to keep the stuff from adhering to his hands. After this it is again washed in cold water, and the pounding, boiling, and washing are repeated until the material becomes sufficiently clean and pure. During the above process about nine-tenths of the weight of the raw material is lost, 250 catties of the latter not turning out more than 25 of good birdlime.

The uses to which this article is put by the Japanese are more extensive and diverse than one would suspect, its principal one being, of course, for the snaring of birds and animals. By its means animals as large as monkeys are caught. When they once get the stuff upon their paws they soon cover themselves with it, and so exhaust themselves in trying to get rid of it that they fall an easy prey. Birds also as large as ducks are taken, and by a very ingenious process. The young shoots of the fugi (*Wisteria*) which attain considerable length, and are strong, light, and flexible, are gathered, dried, and knotted together in one continuous length. This is smeared with birdlime, and floated out to sea, when very often in the morning, as the writer has witnessed on the eastern coast of Choshin, the hunter is rewarded with several birds. It is a very inexpensive method of bagging wild fowl, as the tackle will serve any number of times till the birdlime dries, when it is easily replaced. Small birds are caught in various ways, some by means of a decoy bird concealed near a patch of tempting food, which is plentifully planted with little splinters of bamboo, like large needles, the upper half of which is covered with lime. Others are caught while on trees by means of a long, slender bamboo, the top of which is anointed with the lime, and then stealthily thrust against its feathers. Rats are easily caught by spreading a small quantity on a piece of board or paper, and placing it near their holes. It is spread upon a bamboo leaf, and universally used throughout Japan during summer, for catching flies or other insects. The writer has even seen a flea trap made of it, and used by the Japanese in bed. This trap looked more like an English toast-rack without a handle than anything else, simply a piece of board with the lime spread over its upper surface, while over this semcircles of bamboo were fixed at some distance apart, to prevent the bedding, &c., from getting smeared with lime. Should the vivacious insects happen to get on to this during their nocturnal frolics, their fate is as surely sealed as that of a little fish in the embrace of an octopod.

Another use of birdlime is for medicinal purposes. In certain diseases of the eye it is taken in small pills or dissolved in hot water. It is also used for those complaints of the pelvis, which the Japanese call "senke;" it is considered one of the best cures for flesh wounds, cuts, &c., and is almost universally used in the manufacture of plasters. Both water and oil are used in its manipulation, to prevent it sticking to the fingers, but it is generally handled with a stick. It can be purchased at any greengrocer's ("yawoya") store throughout Japan. It might be as well to mention that a very inferior quality of birdlime is made out of wheat by most of the "fuga" (makers of wheaten food); it soon loses its properties and becomes useless.

ON WATCHES AND WATCH MAKING.

MATHEMATICS is a science of universal operation. It is not half so much theoretical as it is practical. The ruling of nations, the strife of political parties, the guidance of material action forces, and the constructive results of human ingenuity are under the absolute control of this abstruse but intensely practical rule. Machines owe everything to its governance, and all improvements depend upon its calculations. Accuracy and

certainty characterise all its proceedings, and hence it should be the staple of education.

In nothing is the influence of this wondrous science more manifest than in the construction of the excellent chronicler of time. The history of the art of watch-making is the finest illustration of Practical Mathematics. Let us make that observation good.

Watches measure out to man, minutes, hours, and days. How to scatter those strokes among wheels and pinions (or little wheels) in proportion so as to correctly measure, is the province of mathematics. A little patience will give the reader much knowledge of the process by which the exceedingly beautiful result is obtained.

Every wheel has its little one, called in old time the pinion, as in naval matters every ship had its attendant called by the same name. A wheel of sixty feet is fed by a pinion of six, and the pinion has to do ten rounds for one to make matters even; but perhaps it would be better to make some definitions of parts that are supposed to be well understood, but in truth are not. People in our age of universal knowledge speak and are credited with an amount of information they have not acquired.

In calculating a piece of watch-work, the maker first decides upon the number of beats of the Balance there will be in an hour. If for one of the old 30-hour Pocket Watches—a swift motion—he would select about 20,000, or for what was known as the new pendulum Pocket Watches, a slower movement, say 16,000. Having determined his choice, the next point is to decide on the number of turns the great wheel shall have, and the number of hours he will have the piece to go. For instance, suppose 12 turns and to go 30 hours, or 192 hours, which is eight days, &c. A quaint old author puts the case thus: "Having gone so far, you proceed to find out the beats of the balance or pendulum in one turn of the wheel." All the calcuations go thenceforward by the rule of proportion ("the royal rule of three.") Then by the beats and turns the number of hours the watch will go is determined by the same rule, also the strokes of the balance in one turn of the wheel; the beats of the balance in an hour, and all the details that depend upon the kind of watch to be produced, and the length of time it is required to be in motion without winding; and the arrangements showing minutes and seconds. These particulars are obvious when pointed out, but do not recur to ordinary observers at all times. By them the art is reduced to mathematical certainties, the condition of which are that every calculation and form of construction shall be scientifically exact.

M. de Lalande, a renowned astronomer, and member of the Royal Academy of Sciences, published an elaborate "Treatise on Pitchings," in which is determined geometrically the most advantageous turn which can be given to the teeth of wheels and the leaves of pinions (which play into the teeth of a wheel.) He had observed that watch-makers had neglected accuracy because they regarded it as a matter of pure geometry, and involving difficult investigations without yielding proportionate advantage. He laid down the general principle as—1, the force of the wheel to drive the pinion should be the least possible; 2, the velocity should be the greatest the wheel could impart; 3, the force and velocity must be the same from the moment of contact to the instant when the wheel ceases to work or leaves the pinion; 4, the friction produced should be the least possible. He then encourages artists (watch-makers) who are desiring to be perfect in their craft to acquire the little knowledge of geometry which the principles he states demand; ending with the necessary formula, and stating the practical effect of their operation in the hand of a careful student. Construction is simplified, and results assured.

Sir Edmund Beckett (formerly E. B. Denison), President of the Horological Society, justly observes, "Minute details of watch-making can be learnt by nothing but experience; whereas clock-making is easily learnt by any person of mechanical ability." Still it is necessary for the general advantage that comprehensive knowledge be familiarised, if only to repress empiricism, and stimulate the artificer to competitive information.

Confining our observations in this paper to the subject of watches, because that of clocks will follow, we note a few of the ancient watches, and then those of modern days.

The invention of springs as the motive power in clocks about the end of the fifteenth century, showed that time-pieces might be made portable, and that springs could act independently of position. Its discoverer has never been named, but we have record of one in 1494, in the poems of Visconti, an Italian poet; and Hell of Nuremburg made them in 1500. Cocclarus wrote of him, "Ingenious things are now being invented. Peter Hell, a young man, hath made works admired even by the most learned mathematicians, small horologies of iron, fitted with many wheels, which, whethersoever they be turned, without a pendulum, both show and strike forty hours, whether be carried in the bosom or the pocket."

From Nuremburg the art of watch-making extended itself to France, where Francis I. granted a monopoly for their manufac-

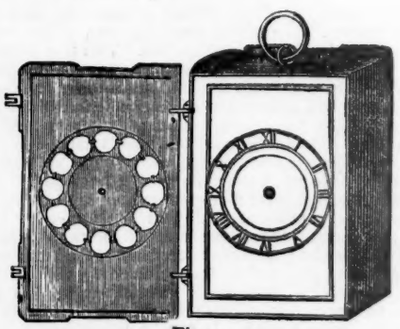

Fig. 1.

Fig. 2.

Fig. 3.

ture to the Society of Clockmakers in Paris. There are several admirable specimens in the fine collection at Guildhall, deposited by the Clock-maker's Company, and at South Kensington; these excel in the enamelling of the exterior; the embellishment is of the finest taste, the perfection of that art upon various precious metals; a few specimens are illustrated from the collection of engravings belonging to Mr. Benson of London, who has obligingly favoured us with permission to employ them here.

Originally watchmakers were blacksmiths. The works were all of iron; glass had not been introduced for casing; here is one in the form of a book. (Fig. 1).

Following the French example, Charles I. of England granted a charter to the London Clockmaker's Company that prohibited the importation of all time-pieces in order to defend the skilled artisans here from an injurious competition; and the charter had the force of a search warrant. Taking an office, they were authorised to enter shops, warehouses, and any place "where they shall suspect bad and deceitful works to be made or kept," to seize them in the King's name, prove their worthlessness, and then destroy them. We prefix two illustrations, the one round, and the other oval, both dated 1593. Fig. 2 is one of the earliest examples, and contains a dial denoting the hour, and a general calendar according to the quaint habits of artistic workers of that time. The other (Fig. 3) possesses the same wealth of information, combining the watch and the almanac.

A heavy elaborate example is the Memento Mori Watch (Fig. 4), presented by Mary Queen of Scots to Mary Seton, one of her

Fig. 4.

maids of honour. It is of the form of a skull; on the forehead is the figure of Death, standing between a palace and a cottage; a legend from Horace surrounds. On the hind part of the skull Time is similarly signified and legendised. The upper part of the skull represents Adam and Eve in Paradise, and the crucifixion, with Latin legends; and between the scenes open work occurs to let out the sound of the silver bell that is struck by the watch every hour. It can be shut up when quiet is desired. Many allegorical examples occur conveying pictorially some Scriptural incident, but for the most part of the sombre mediæval type, bordering on superstition.

As a subject of curiosity quite as much as illustration of the changes in art fashion, Sir C. Fellows had obtained what unquestionably was once the property of Oliver Cromwell. It is one of the early examples of a fob-watch; was made by Midwall, a warden of the Clockmakers' Company, cased in silver, and having a silver chain; the face is covered with glass (Fig. 5). The arms and crest are those figured at the Protector's funeral.

Fig. 5.

Bunting, also a member of the Clockmakers' Company, and resided in Popes' Head Ally, in Cornhill, made a watch for presentation to John Milton, when he left Christ's at Cambridge to reside at Horton. This came after a curious history—authenticated nevertheless—into the possession of Sir Charles Fellows, who held the highest authority as a connoisseur and collector of ancient time-pieces. It is now in the British Museum. The engraving is the exact size of the watch (Fig. 6). The dial is of polished iron, in silver case.

Fig. 6.

An additional item of mechanism "whereby a person at night might ascertain in the dark the hour last struck by pulling a certain part of it, was invented by Mr. Barbour in 1676, and obtained the name of "Repeater." He was denied his patent by James II. at the instigation of the Clockmakers' Company. A further improvement occurred in 1695, when Pompion invented the cylinder escapement, with horizontal wheel. From it is dated the more portable because flatter construction of watches.

Fig. 7 is the original jewelled watch, one of the most valued

Fig. 7.

of the Clockmakers' treasures. One Facio and two other Geneva manufacturers came to London with a patent for jewelled watches, and obtained a charter for fourteen years. At the expiration of that date he applied for renewal of his patent, and encountered the opposition of the Clockmakers' Company on the ground of want of novelty. This very watch had to be put in evidence, and by it Facio lost his case; subsequent examinations proved that the jewel had been stuck on for the purpose of deception, and had nothing to do with the pivot. But English makers caught up the idea, and though the poor Genevese had to endure mortification by his defeat, the trade lost all right to monopoly, and everybody acquired liberty to jewel their goods if they knew how, and could manufacture on that principle. No doubt but the English trade acquired a great impulse from this circumstance, as watches being made by every one not only

created a larger market, but makers could afford to supply at cheaper rates under such circumstances.

Up to this date there had been no chronometrical instrument on which reliance could be placed, although speculative philosophers repeatedly attempted its production. Several efforts in that direction failed until 1720, when the subject revived under the joint influence of private and public experiments. Graham made a Mercurial Compensation pendulum, which consisted of a glass or iron jar, filled with quicksilver, and fixed to the end of the pendulum rod. Heat lengthened the rod, expanding the quicksilver, and made the centre of oscillation to continue at the same distance from the point of suspension. At his suggestion Harrison improved the instrument in 1726, by his invention of the gridiron pendulum, composed of nine rods, five steel, and four of brass, arranged so that those expanding most would be counteracted by those of less expansion. These two are still in use, and practically keep accurate time.

The importance of the chronometer to navigation claimed and obtained public and parliamentary attention. Prizes continually appealed to the effort of the inventor, stimulating him to renewed toil. Harrison demonstrated the value of his invention by voyages that proved the soundness of his principle, and enabled him to claim and to have the liberal sum of £20,000 by parliamentary vote, as a reward of his successful enterprise.

An inspection of the fine collections at the British Museum, South Kensington, and Guildhall, demonstrates the improvement by a contrast between the past and present construction of watches. Toys like a walnut shell, or a plum or an egg made of rough materials by rough hands, have given place to a universal acceptance of the round flat watch of our day: a watch that avoids the error of ten years ago, when tiny instruments were most approved, and is accepted being a sound moderate size wherein the works can go well, and be of sufficient strength to bear ordinary wear-and-tear.

Some idea of the universal acceptance of the watch is to be acquired from the fact that the estimated trade therein is £5,000,000 a year.

With a few notes on the parts of the watch, we close this paper. Four kinds are familiar, and most of the parts similar. Figs. 8, 9, 10, and 11 are the well-known kinds.

Fig. 8.—THE HORIZONTAL WATCH.

Fig. 9.—THE SKELETON LEVER WATCH.

Fig. 10.—THE FULL PLATE ENGLISH LEVER.

Fig. 11.—THREE-QUARTER PLATE ENGLISH LEVER.

"The motive power in the watch is derived from a spiral spring, called the MAIN SPRING, set in a drum or barrel, and any inequality in the pressure of the spring is fatal to time-keeping. A highly tempered and finished spring is a primary requisite in watch-making. In order to provide for the uniform transmission of motive power from the barrel throughout the train to the escapement, the fusee and chain are used, the fusee being a hollow-sided cone, and the chain round it. When the spring is wound up its force is of course greatest, for the chain is then acting on the small end of the fusee or wheel." All these proportions have to be well planned, as described above.

The ESCAPEMENT is one of the most important parts. They are the *Verge*, Fig. 12, the *Horizontal*, Fig. 13, the *Duplex*, Fig. 14, the *Lever*, Fig. 15, and the *Chronometer*, Fig. 16.

1. The *Verge*—A, part of the balance; B, the verge body; C, the pallets; D, the escape-wheel; E, escape well pinion. The verge or arbor B of the balance has two pallets C, which stand out at right angles, so as to be acted upon alternately by the sloping teeth in the opposite sides of the crown or escapement wheel C.

2. The *Horizontal* is so called, because of the escape-wheel acting horizontally to the axis of the balance; *a*, the escape-

Fig. 12.
THE VERGE.

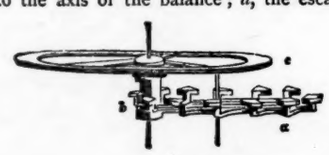

Fig. 13.
THE HORIZONTAL ESCAPEMENT.

wheel, having pins, *i.e.*, stems rising from it, on the tops of which are wedged-shaped teeth, long enough to permit only a very little freedom within and without the cylinder *b*, which is firmly fixed to the balance *c*. Although *b* is one piece, the two edges of the hollow parts serve as two distinct pallets, inasmuch as they receive alternately at each vibration an impulse from the

curved outer edge of each tooth. As the tooth passes, the coming tooth falls on to the circular part of the cylinder, and there remains until the return of the balance, so on in succession alternately.

3. The *Duplex*, which nearly approaches the chronometer. A, the escape-wheel; B, the escape-wheel teeth; C, the balance; D, the pallet of impulse; E, the ruby roller; F, a notch in ditto; 1, 2, 3, cogs, or upright teeth on the rim of the escape-wheel. The balance is supposed to be turning downwards towards the right, the tooth of the escape-wheel just resting against the ruby roller. When this vibration is complete the balance is carried by the hair-spring in an opposite direction, and as the notch passes the tooth of the wheel, the roller is passed, and the upright cog falls upon the pallet D, and gives impulse to the balance. The next straight tooth then rests against the roller, and the same operation takes place. This is much superior to the horizontal, being nearly independent of oil, and carries heavier balances.

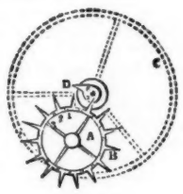

Fig. 14.
DUPLEX ESCAPEMENT.

Fig. 15.
LEVER ESCAPEMENT.

4. The *Patent Detached Lever—a, a*, the escapement-wheel, *b, b*, the ruby pallets; *c*, the lever; *d*, the balance. On the axis of the balance *d*, towards the lower *c* is a small disc of steel, into which is inserted a small piece of ruby, which fits into a notch at the end of the lower on which two pallets are fixed, into which are secured very finely polished rubies. This escapement is most interesting, and so excellent was it considered, that chronometers were made upon it, and placed in the Royal Observatory for trial. Since then improvements have followed, and the patent detached lever made into a pocket watch will not vary five seconds a week. The last is the chronometer escapement. Fig. 16, which is the nearest approach to perfection, the impulse to the balance being given at the centre of vibration. A is the escape-wheel; B, the escape-wheel teeth; C, the roller set on the verge or axis of the balance, and is made of polished steel, with a notch cut out of it, into one side of which D, a flat polished piece of ruby, is inserted for the acting part. Below this steel roller is a smaller one having a sapphire on the outer edge. F is a slender spring screwed at I to the stouter one, having its fixture at L polished away at K to make it bend readily. G is a projecting piece carrying a ruby pin against which the wheel B rests. A and B is a small screw against which the spring L K G strikes and thus prevents it from springing too far back.

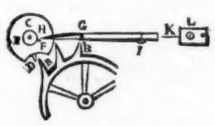

Fig. 16.
CHRONOMETER ESCAPEMENT.

Among the sundries have been appliances introduced to correct the errors caused by variations in the temperature: the best of which is that known as the *Compensation Balance*, invented by Earnshaw of London, and rewarded by Government. It will keep time whether the temperature be 32° or 90°. Any good watchmaker would exhibit its action.

Dials and hands are made of gold and silver, but these are not so distinct as those made of white enamel, with black figures or numerals, and dark blue steel hands. Seconds' hands are now everywhere sunk to make them more distinct.

Jewelling is a very important part of watch manufacture, as they secure durability; a hard kind of ruby is preferred for best watches, as it will wear a hundred years, while common jewels are no better than metal.

We need not particularize the frame and the case so familiar: and shall only enumerate the titles of *Complicated Watches*, which are now occupying a most important position in the trade, possessing as they do more or less complicated mechanism, by means of which they can indicate special portions of time,—as, for instance, Chronograph, fig. 17, which marks the fifth of a second; the Quarter, and half-quarter, and minute repeaters, which give the time in the dark to within a minute, and are in-

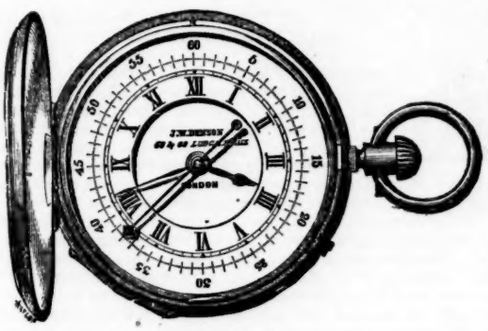

Fig. 17.

valuable to invalids and blind persons; the Clock-Watch, which strikes the hours even in the pocket; the Clock-Watch Repeater,

Fig. 18.

which strikes and repeats; the Perpetual Calendar, fig. 18, and the Meridian, fig. 19, which shows the time in any given number of places in any part of the world.

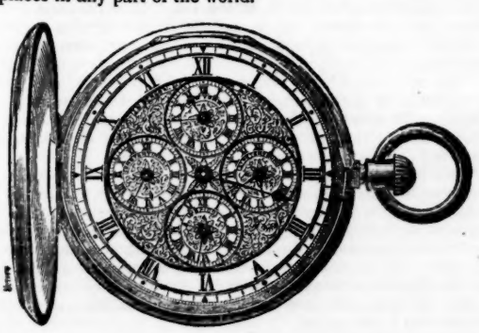

Fig. 19.

Note.—We have compiled this article from J. W. Benson's Time and Time-Keepers: William Dermar's Artificial Clock Maker; the Guildhall Catalogues; Sir E. Becket's Treatises; Melthropp's Watch and Watchmaking; and some reference books. The engravings are obligingly supplied by Mr. Benson.

LORD BATEMAN ON THE POLITICO-COMMERCIAL POLICY OF ENGLAND.

IN the abstract Free Trade is wisdom: in a few cases our practical men have found it folly. The question is not political; it is social. Lord Bateman says—

"At this moment of widespread commercial depression, the question of the expediency of a return to a system of limited Protection, as opposed to that of free trade, is undoubtedly once again forcing itself upon the consideration of many thoughtful minds.

"Notwithstanding the appeals, from her Majesty's Chancellor of the Exchequer downwards, which continue to be made on its behalf by the advocates and apologists of this free trade policy, it is evident, from their recently-expressed opinions, that a certain uncomfortable feeling of doubt exists as to its success, and the excuses put forward for the general non-acceptance of the free trade doctrine raise an unmistakeable mistrust in the soundness of their views, and lead us to inquire whether a policy which requires so much excuse to be made for it is, after all, the one best fitted to our peculiar interests, or one in which this country should still continue to persist. I have used the words 'limited protection' advisedly, in order at the outset to guard against any supposition that either myself or those who think with me consider it would be either politic or possible, in the impending war of tariffs or in any revision of our customs duties, to attempt to impose any restrictions whatever on what I will call vital necessaries, or on the recognised food of the population. In any scheme of commercial policy due consideration should always be given to the capabilities of production of the country on the one hand, and to its absolute necessities on the other.

"In the case of Great Britain, owing to our area being so much restricted and to the continued increase in population,—an increase out of all proportion to the size and acreage of the kingdom as compared with the relative proportion of population to the area and extent of foreign countries,—it has become virtually imperative upon us to obtain from all nations of the earth the requisite food supply. Thus far, therefore, it is willingly conceded that the exercise of free trade, though still incomplete, has conferred on the masses an exceptional and a lasting benefit. I turn aside for a brief instant to pay this tribute to the memory of the late Mr. Cobden and Sir George Cornewall Lewis, and to the foresight of Mr. Bright and Mr. Charles Villiers.

"But, unfortunately, we have to deal with many more interests than those exclusively connected with the food supply of the people. We have to deal with our own natural and sufficient products, with our various home manufactures, and with our own skilled—and daily more expensive—general labour question. These latter, quite as important to the well-being of the community, require to be as jealously guarded and protected, exercising, as they undoubtedly do, an equally preponderating influence on the prosperity, or otherwise, of all classes in the kingdom. It behoves us, therefore, while securing for them the best available market, to be at the same time cautious how we allow them to deteriorate, or permit rival countries unduly to compete with our native industries to our own loss and detriment.

"Sir, we cannot shut our eyes to the universal collapse of trade and its accompanying distress, be it the mineral, the shipping, the carrying, the agricultural, or the general manufacturing trade. Throughout the country the cry of depression and distress and ruin is the same.

"We have to compete on unequal terms with other foreign countries, who are robbing us of our profits, pay nothing to our Exchequer, and underselling us at the same time. When the capitalist finds that his trade is leaving him, and that his profits are reduced to a minimum, it follows that the workmen depending upon him must suffer in like proportion, and as a consequence the rate of wages must come down or employment must cease. Strikes, lock-outs, and painful and undeserved distress are the inevitable results.

"Granted that the theory of free and unrestricted commerce with all the quarters of the universe is as bold as it is magnanimous; granted that the idea, by whomsoever originated—and advocated by no one more consistently than by our late good and wise Prince Consort—is both grand and glorious in its conception; granted that to give effect to it has been the aim, as it has been the long accepted policy, of successive governments, it cannot be denied that the sting of 'want of reciprocity' has, from the first, checkmated our philanthropic efforts, and obliged us now to confess, after thirty years of trial, that in practice our free trade is at best but one-sided, and that, while we are opening our ports to the commerce and manufacturers of the world free and unrestricted, other countries, without conferring upon us any reciprocal benefit, are taking advantage without scruple of our magnanimous, but disastrous—because one-sided—liberality.

"It is of no use to blink the question. Facts will speak for themselves. In defiance of all arguments and all persuasion, not to say entreaty, on the subject, these awkward facts still remain. Our overtures to other countries are disregarded. Our Commercial Treaties are not renewed. Our own trade is in a sinking and unprofitable condition. Our exports show a lamentable and alarming and increasing deficit. Our Exchequer is affected. And, worse than all, not a single country in Europe, beginning with France and Germany, and ending with Spain and Switzerland, to say nothing of the United States of America or our own Australian colonies, can be cajoled by the most specious temptation into following our example of free importations, or opening their ports to the commerce of Great Britain and of the world unrestricted by safeguards in the shape of duties framed to protect their own native industries.

"Now, Sir, in view of these undeniable facts, and of the *quasi* admitted failure of the policy which has been so long a time in operation, and which was, in fact, initiated, and I may say necessitated, by the exigences of an exceptional period of famine and distress, which even the most ardent protectionists of the time were quite unable to gainsay or withstand, but which happily now no longer exist, I ask whether that grave moment of reflection and self-examination has not arrived when it behoves all classes who feel themselves sensibly affected, to pause and seriously review the present position, and if a false step has been made, as many think, to have the courage and the energy to retrace it without delay. This is neither more nor less than what a prudent man in private, or a prudent trader in commercial life, would find it his imperative interest to do. How much more imperative, therefore, is it when imperia and patriotic interests are so heavily involved!

"We have tried free trade, and it has been found wanting. We have done our best to impress other countries with the reasonableness of our policy, and in return they scoff at our blindness and turn a deaf ear to our remonstrances. In the meantime, partial ruin and wholesale depression and distress are staring us in the face. Our local burdens are increasing, our exports diminishing. Our working classes, unsettled, are waging open war in the cause of labour against capital, discontented because unable to find the real cause of their discontent, clamouring for their participation in profits, which can hardly be said to exist, and yet unable to account for the hesitation and inability of their employers to accede to what they consider are only their just demands.

"Why should we persist in such an Utopian crusade? Why have we cut adrift from our old anchorage to launch our good ship upon a treacherous torrent, which is hurling us helplessly to imminent shipwreck? In Heaven's name, if we are on the wrong track, let us arrest our downward course. Do not let us, for the sake of a Quixotic theory, blind our eyes to the fact that our trade is ruinously slipping from us, and that we are sacrificing our best and dearest interests to an unacceptable idea.

"There are indications that the tide of public opinion is undergoing a gradual, and therefore a more convincing, change. I hail it with satisfaction. After all, the argument that comes home to every one's pocket is the most cogent, and is worth all the theories and all the lectures of all the political economists in the world.

"I appeal to the common sense and to the patriotism of my countrymen, and if they are convinced how great has been the fallacy of our free trade policy without reciprocity, it is for them to say, as I believe sincerely they will say, whether a return to a policy of limited protection, so far from being impossible or undesirable, is not the true and simple solution of our present difficulties, which will tend, in a more simple and natural way than any other, to retrieve our losses, increase our revenue, lighten our burdens, bring peace, contentment, and employment to our working classes, and teach them and us to bless the day which restored the old policy and the old watchword of 'protection to native British industry.'

"With the object of bringing these views before the public, and of inviting their discussion and consideration, I have ventured to address you."

[His Lordship somewhat hides from his own clear vision what the world recognises; and that is not wise. Freedom is in itself fine, and its assertion our duty. Protection is selfish and impoverishing. The statesman's function is to govern in a manner that shall give freedom, and defend the helpless.]

INDIAN COTTON AND SILK.

THE State Paper upon the moral and material progress of India, for the year 1875-76, devotes a brief space to the subject of the cotton and silk manufactures of the peninsula. In Bengal the cotton manufacture is carried on at the present time to a very limited extent. Three pieces were ordered by a native gentleman for presentation to the Prince of Wales; each piece measured 20 yards by 1, but the fineness of the texture was such that the weight was only 3½ ounces. In the town of Bombay, and Coorla, a village in the neighbourhood, there were, during the year, 24 cotton mills working, containing 689,950 spindles, and 7,039. In the up-country districts eight mills were at work, with 125,153 spindles and 640 looms. Since the close of the year another mill, with 10,000 spindles, was opened, and six more were in course of completion, which would altogether raise the number of spindles to 963,983. These mills do a large trade in yarn and in the coarse cloth, and find ready markets for all they can produce. The number of steam gins was 2,585, being an increase of 206. In the number of presses licensed and worked in British territory there was a decrease of 28, of which 22 were hand-presses, and six presses worked by steam. The diminution in the number of full presses was confined to the capital, and was due to the increase of full pressing up country. Of 1,010,284 bales exported from the Presidency, more than 500,000 were full pressed before they reached Bombay. In connection with this subject, it is mentioned that there is at Nagpore, in the Central Provinces, an association of native gentlemen co-operating with societies in the Bombay Presidency, with the object of encouraging the trade in country-made clothes, to the exclusion of the European manufactures. The association does not aim at any profits at all, but the motive is said to be purely, a patriotic support of the Indian manufacture; and the members wear, as far as possible, only country-made stuffs. This movement shows that the decline of native manufactures is a popularly accepted fact. Behar is essentially a non-manufacturing district. The weaving industry, which in former days was the chief occupation of the inhabitants of the larger towns, has gradually given way before the importation of English and Bombay piece-goods, and is now almost limited to coarse descriptions of cloth. There were altogether 29 full presses at work, which on an average pressed 7,357 bales of cotton. One press opened during the year was the first established under native management.

Various causes have combined of late years to affect the Bengal silk industry, namely, the growing preference in Europe for woollen fabrics, the competition of Chinese and Japanese silks, the increased production in Italy, and frequent attacks of the silkworm by an incurable disease. There was, however, some prospect of a revival in consequence of a failure during the year in France and Italy. Silk-weaving, although it has shared to some extent the fate of silk spinning, is still an important industry in Bengal. A considerable impulse was given during the year to sericiculture in the Punjâb, by the establishment of a factory for reeling silk from the cocoon, and by the offer of annual prizes by a committee to producers of cocoons. The tussur silkworm being found to exist in considerable numbers in the several districts, operations were commenced for rearing the worm on a large scale, with a view to the possible development of a new industry in tussur silk.

AUSTRALIAN JUVENILE INDUSTRIAL EXHIBITION, BALLARAT.

BALLARAT is the chief gold-mining city in Victoria, and has, including its suburbs, a population of 50,000. It is also the centre of an important agricultural and pastoral district. It is intended to hold this Juvenile Exhibition in February next, and few things could be devised more appropriate to the comparatively young colony of Australia than this competitive display of what its youth can effect. The idea will assuredly commend itself to the English public for our imitation. Many are insensible to the existence of juvenile skill, because the rising artist or artizan is, by reason of his age, circumstances, and position, comparatively isolate and obscure: but the indications of power and refinement, or of excellence in any line, usually appear before the age of 21 has been reached, and in thousands of cases before that of 15. If, by encouragement, a part of the dreary uphill work between 20 and 30 can be bridged by the worker's acquisition of earlier fame and position, something good is done not only to the fortune but to the character of the novice. Success has a refining effect, in the majority of cases, by inducing a higher self-respect, and stimulating to greater effort.

Well-known colonial men have joined this movement. The Governor has accepted the office of patron, assisted by all the men of distinction as vice-patrons. W. J. Clarke is President, and he has an equal number of vice-presidents, besides a first-class executive.

The following are the official regulations for the guidance of intending exhibitors—

1. The Executive Committee of the Australian Juvenile Industrial Exhibition invite the young people, of both sexes, all over the Australian colonies, to contribute articles of their own handiwork.

2. The Exhibition will be opened in Ballarat on or about the 15th February 1878, and remain open about two months. All exhibits must be delivered at the Exhibition Building, Ballarat, on or before the 31st day of January 1878, or shipped on that date if coming by sea from other colonies; exceptions will be made for perishable articles, which will be received up to the day before opening of Exhibition.

3. Application for space must be made on or before the 31st day of December, 1877. Applicants must be under twenty-one years of age at the time of applying for space, except in sections B and E.

4. Forms of application for space, or any information, can be obtained from the Honorary Secretary, 5 Sturt Street, Ballarat, or from any of the agents advertised, either personally or by letter.

5. The Executive Committee will assert the right to limit space and to exclude any unsuitable, dangerous, or explosive exhibits not forwarding or returning the exhibit.

6. Exhibitors can jointly make any article for exhibit, or exhibit any portion of an article separately; the joint work of apprentices can be exhibited from any establishment or workshop.

7. Exhibitors will not be charged for space, nor should more be applied for than required, and it is desirable that all granted should be oocupied; a limited quantity of steam power will be supplied, if necessary.

8. Young people are invited to contribute models, working or otherwise, of any description, in any material, not to exceed one cubic yard of content.

9. The Executive Committee will take the greatest care of all exhibits, but cannot hold themselves responsible for loss, robbery, accident, damage by fire or otherwise, in transit, while in the building, or during the Exhibition.

10. Exhibitors may sell their exhibits under regulations to be made by the Committee, but no removal will be allowed during the time the Exhibition is open, without a special written order from the Honorary Secretary.

11. Medals in gold, silver, and bronze, will be awarded by the Executive Committee, on recommendation of the Judges, for exhibits of merit.

12. Sketches, drawings, photographs, or other reproductions of articles exhibited, will only be allowed upon the joint consent of the exhibitor and the Executive Committee.

13. Exhibits should be carefully packed to prevent injury, arranged and protected to preserve them from dust and exposure; glass cases must be provided by exhibitors, if required.

14. Arrangements will be made to carry exhibits by railways, steamer, or coach, at reduced rates, if possible.

Extra prizes are requested from the public to enhance the attractiveness of the exhibition throughout the juvenile population.

Section A.—Under 21 years of age, at the time of applying for space.

Section B.—Apprentices not out of their indentures, whatever their age.

Section C.—Between the ages of 15 and 18 years.

Section D.—Under 15 years of age.

Section E.—Non-competitive Exhibits.

Class 1. Machinery of every description, mining, agricultural, and other implements, and models of same, also models of mines and workings.

Class 2. Carriages, vehicles, and models of same.

Class 3. Building materials, decorations, and models of buildings.

Class 4. Furniture and household requisites in wood, inlaying, rustic, basket work, &c.

Class 5. Harness, leather, skins, furs, boots and shoes, and all articles in leather.

Class 6. Men's clothing, hats, &c., also materials for same.
Class 7. Ladies' dresses, millinery, children's dresses, underclothing, dressed dolls, and every description of plain and fancy needlework, knitting, netting, &c.
Class 8. Ladies' ornamental and artificial work, in wax, feathers, paper, wool, leather, or other material.
Class 9. Food, luxuries of consumption, confectionery, jams, jellies, preserves, cakes, biscuits, pastry, bread, butter, cheese, pickles, hams, bacon, &c.
Class 10. Instruments—Philosophical, mathematical; cutlery, tools, and all instruments in metal, glass, and other material.
Class 11. Musical instruments and musical compositions.
Class 12. Boats—steam, sailing, and rowing (not to exceed 30 feet), models of same, and life-saving apparatus.
Class 13. Fine arts, painting, drawing, modelling, sculpture, penmanship, printing, lithography, mapping, photography, bookbinding, and engraving.
Class 14. Jewellery, clocks, watches, and ornaments in the precious metals and minerals.
Class 15. Castings and fittings in brass, copper, zinc, iron, tin, and all metal wares, smiths' work, &c.
Class 16. Glass, pottery, and all articles of plastic ware.
Class 17. Toys of wood, metal, or other material, and models of every description.
Class 18. Pot plants grown from cuttings and seeds by exhibitors, and seeds of every description. Wardian cases, &c.
Class 19. Collections and devices in shells, mosses, dried ferns, sea weeds, animals, birds, insects, or any natural production.
Class 20. Turning and carving in stone, marble, ivory, bone, metal, wood, horn, compositions, or other materials.
Class 21. Textile fabrics, spun and raw silk, and wool, ropes, matting, brush ware, &c.
Class 22. Mineralogical and geological collections, chemicals, dyeing, tanning, artificial manures, &c.
Class 23. Essays, poems, and compositions on any subject.
Class 24. Articles not epumerated.

THE PRESERVATIVE POWER OF FERNS.

DOUBTLESS many of the readers of this journal, when passing the shops of large fruiterers in London and elsewhere, have observed apples, pears, and other fruit packed in hampers containing fern-leaves, and had they but inquired why these leaves in particular were used, the more intelligent of the vendors would probably have told them they assisted in preserving the fruit from mildew and decay. Some years ago, when residing in the Isle of Man, I noticed that the bracken ("*Pteris aquilina*") was in large demand for packing the fresh-caught herring forwarded daily by steamboats to the Liverpool markets; and more recently, during a brief sojourn at Frodsham, in Cheshire, brackens were collected on the Overton hill to line the hampers of new potatoes transmitted to the Manchester markets. Upon my return to the north of England, in a year when the potatoe disease was threatening the destruction of that valuable esculent, the rector of a parish in my neighbourhood, at my suggestion, induced one of his farmers to "hog" his winter potatoes on the ground where they grew, and to cover them with bracken instead of the customary straw. The farmer, sceptical about the result, only covered half the "hog" with ferns, leaving the other half protected by straw; earthing and sodding up the ground to exclude rain and frost. Winter arrived, and the "hog" was opened for a fresh supply of tubers, when it was discovered that those potatoes which had been stored in brackens were sound and good, whilst those protected by straw were so much decayed as to be scarcely worth the labour of removing. To me the experiment was very satisfactory and suggestive.

That ferns contain some peculiar preservative property there can be little doubt. Both the bracken and male fern abound in alkaline matter, which was once used by the manufacturers of soap and glass, and their astringent properties are well known to country people, and the dressers of leather. I believe the aroma from this family of plants to be repugnant to most insects and inimical to the growth of that species of fungi known as mould. I cannot now recall to my recollection ever having seen the larvæ of any lepidopterous insect feeding upon the fronds of our common ferns, nor do I remember having noticed insects of any order resting upon them unless it were for shelter during a shower of rain. The peculiar odour thrown off by ferns must be familiar to all who have wandered near their places of growth. Is it due to an essential oil? The Russian leather so much prized in this country for its enduring properties and grateful smell is said to be prepared with oil distilled from the birch tree, and it has been stated that bales of this valuable leather frequently lie for months in damp weather at the London Docks without spotting or otherwise sustaining injury from mildew. Librarians know by experience its inestimable value for covering books intended to last a hundred years; it rarely is attacked by that enemy of calf. Essential oils of all kinds will prevent the growth of fungi, and we have only to mix a few drops in our flower-paste and see how long it will remain unattacked by these sporals: no doubt if ferns were boiled with the paste the same protection would ensue.

Dried ferns make a most enduring thatch for outbuildings on the farm, and should, indeed are, largely used for littering the pig-styes, and all places where animals are confined that are liable to the attacks of entoziac diseases. In Germany and Denmark the leaves of the beach keep the house bedding free from noxious insects, but the ferns would do better.

MR. BELL'S TELEPHONE.

CANDOUR requires us to add to the remarks made two months ago on the subject of telephony some particulars of Mr. Bell's claim. Sir Charles Wheatstone's suggestions and experiments, with those of Mr. Cromwell Varley and also of Dr. Grey, have been described. Mr. Bell claims as his speciality not the invention or the original idea, but that he is able to transmit the sound of the human voice; that is, he can cause spoken words to be reproduced at a distance. An apparatus which can effect this purpose may ultimately be of the highest practical utility; and as Mr. Bell derived his first suggestion from a consideration of the mechanism of the human ear, and has simply done his best to imitate that mechanism, it is not improbable that we may by-and-by attain scientific results of much value, because science, to be successful, must keep to the lines prescribed by nature.

The apparatus is very simple. Around one end of the magnet is wound a bobbin of fine insulated wire, the ends of the wire being led to the line and to the earth respectively as shown, Opposite the pole of the magnet is a disc of thin iron (the ordinary tinned iron, popularly known as tin, is as good as any), which is fitted in the wooden case so as to be held only by its edge. Opposite the centre of the disc is an opening in the lid of the case, which is expanded in a trumpet-shaped form. This is the whole apparatus, one serving for sending and a second for receiving. The sender speaks in at the trumpet-shaped mouth, while the receiver holds the mouth of his instrument to his ear, in fact, using the instruments much in the same way as the ordinary speaking tube. The words are distinctly audible without effort, but only when the instrument is close to the ear, though some persons of very quick hearing can catch what is said at a distance of a couple of feet. This may certainly be said to be the outside limit that has yet been reached by the telephone, though there is, of course, the possibility that it may be greatly developed and improved. If an instrument is placed in the circuit from a battery—say of one or two Léclanché cells—making and breaking contact produces a sound which, if the breaks succeed in rapid succession, pass into a rattling or pattering sound, which is distinctly audible at a distance from the instrument. A similar sound is produced if a telephone is joined up to a telegraph-wire which passes near other wires in use, the induced current caused by these wires being strong enough to affect it. A still more remarkable proof of its delicacy is that if a single cell be short circuited, and a long circuit be also formed from the same terminals, and including the telephone, any break of contact in this longer circuit is distinctly audible. It is thus an instrument of most wonderful delicacy, as it is audibly affected by currents which would not be shown at all on a common galvanometer.

Since writing the above Professor Bell has met the Society of Telegraphic Engineers at their rooms in Westminster, and giving a narrative himself, which will perhaps be found useful in conveying a clear idea of his experiments and their success.

Prof. Bell stated that, while a youth in Edinburgh, he had been engaged in a series of experiments with his father to determine the movements of the vocal organs when pronouncing vowels. He was, however, afterwards informed by Mr. A. J. Ellis, F.R.S., that not only had these motions been determined, but that they had, to a certain extent, been artificially produced by Helmoltz. Prof. Bell was thus led to a closer study of electricity and magnetism. He described the means employed to

reproduce musical sounds, viz., vibrating reeds of metal tuned to certain notes making and breaking contact, thus alternately sending and stopping the current. These vibrations are exactly reproduced at the distant station by a reed tuned to the same note. The lecturer mentioned that in his experiments he had been led to distinguish six different species of electric currents, which he designates intermittent, direct and inverse; pulsatory, direct and inverse; and undulatory, also direct and inverse. Of these other investigations have distinguished intermittent and pulsatory, but none, so far as he was aware, except himself, had utilised the undulatory.

The first experiments for reproducing sounds were made with vibrating reeds, and has the defect that the signals could only be sent in one direction. This difficulty was overcome by using an induction coil which allowed signals to be sent in both directions. Theory, however, pointed out that not only one sound could be sent along the wire at a time, but that even forty or fifty separate sounds could be transmitted at once; yet in practice he was never able to send more than six or seven, and even this number with difficulty. The reason of this was simply explained—sound being propagated by waves, the waves as produced interfere with each other, lengthening in some cases, shortening in others, but if more than six or seven sounds were attempted, instead of getting distinct notes one continuous sound was produced. This interference reached its maximum when using the intermittent current, and therefore the multiplication of signals was limited, as is also the case when using the pulsatory current, but there is a marked difference when using the undulatory current, the sound curve is certainly changed but it does not disappear.

Seeing, then, that musical sounds could be transmitted, the first form of telephone was an arrangement of strings like that in a harp; for it was supposed that when a sound was produced near the strings a sympathetic movement of the string tuned to the corresponding note would take place, and this would be transmitted along the line, giving rise to a similar note at the further side. Owing to the expense of constructing such an instrument it was not proceeded with. Then Helmoltz's experimental researches in producing the vowel sounds, came to the rescue, and we have the first forms in which a vibrating diaphragm is used. The mechanism of the human ear was carefully studied, and it was noticed that the membrane moved with the same waves is very disproportional as regards weight with the voices which it sets in motion. A human ear was prepared and experimented with, and after some difficulty the vowel curves produced by the movement of the voice were accurately represented. An electro-magnetic coil was now used with a diaphragm in the front of the wire core, to which was attached a small piece of iron. The movement of this small piece of iron caused variations in the induced current in the coil, and a step forward was registered. Prof. Bell gave some of his experiences and those of friends during these experiments, and showed that hope and expectancy caused the listener to fancy he could distinguish sentences when probably the sentences were not uttered. However the movable piece of iron was enlarged, the diaphragm itself gave way to the iron alone, the wire core of the magnet was exchanged for a permanent stud magnet, thus allowing the battery to be altogether dispensed with, the coils instead of being continued along the whole length of the magnet, gradually grew smaller and smaller, till now they form a narrow band at one end of the magnet. All these proceedings were the cause of improvements in the quality of the sound transmitted. The voice waves impinging on the movable piece of iron, cause it to vibrate, the vibrations cause it to act on the electro-magnet at varying distances, and hence induces a varying strength of current which, transmitted, acts upon similar instruments at the other end—reproducing the sound waves, and hence the sounds in the ear.

The lecture was illustrated by a large number of diagrams thrown on the screen, and the audience listened and heard the re-production of the notes of "Auld Lang Syne" played in another room. A cordial vote of thanks, proposed by Mr. Latimer Clark, C.E., and seconded by Mr. W. A. Preece, C.E., was carried with applause.

And notwithstanding the persistency of Mr. Bell and his somewhat unkind references to rivals who have most certainly taught him "the way he should go," is it not good that such as Mr. Latimer Clark and Mr. Preece are glad to recognise his ingenuity and accept the assurance of his power? They have always the enthusiasm which can afford to give cheering words and kindly acts in hope that the fruit will be to the good of a co-labourer.

THE TELEPHONE.

BY PROFESSOR A. GRAHAM BELL.*

TELEPHONY is receiving at the present time a great deal of attention from men of science all over the world, and it is my intention to-night to try and give you a short account of the means by which sound can be produced at a distance by electrical means. There are probably many here present who may recollect the early telephonic experiments made in this country by the late Sir Charles Wheatstone. These experiments were repeated, and, perhaps, improved upon, in America, by Prof. Henry, of the Smithsonian Institute, and others. I may direct your attention for a moment to one of these earlier telephonic experiments in America. Two pianos were placed, one on each side of the road. A long deal rod was taken across the street, from the window of one house to that of the other, and the two ends of the rod were connected to the sounding-boards of the pianos. Under these circumstances, when a person played the piano in one house, the piano in the other house seemingly played by itself. The vibration of the sounding-board was communicated mechanically through the long wooden rod, and, at the other end of this wooden circuit, the sounding-board of the other piano was set into vibration, and the strings of the piano, which were in unison with those of the first one, were thrown sympathetically into action, and produced music.

Another telephonic experiment that I shall direct your attention to may be seen going on in the streets of London on almost any day. You may see persons in the streets exhibiting what is called the telephone, consisting of a small membrane with a thread or a string attached to the end of it, and at a distance of 100 yards or so there is another membrane. The two membranes are united by this thread or string, and if you talk to one of these membranes it is thrown into vibration, and that vibration is mechanically communicated through the string to the other, and the sound is produced in the other membrane. But there is a difference between the early telephonic experiments and those I wish to direct your attention to to-night. If you observe for a moment the *modus operandi* of the thread telephone, you will see that there are two membranes which control one another's action through the vibration of a string. One of these membranes is forced to vibrate; it pulls the other by the string and releases it, and the two vibrate together. In this case, then, the sound is mechanically conducted along the string, but in electric telephony the sound is not communicated along the wire at all. It exists in the wire as a current of electricity, which produces, *de novo*, the vibration of a sound at the receiving end of a circuit.

In examining the means by which sound can be electrically produced, I would direct your attention to several distinct species of what may be called telephonic currents of electricity. For this purpose I will have the lights lowered, and a graphical representation of those currents will be thrown upon the screen. I distinguish three varieties of telephonic currents, which I will designate intermittent, pulsatory, and undulatory. You have these three varieties shown in the three lines of the diagram, the upper one being the intermittent, the second, the pulsatory, and the third, the undulatory. The horizontal line indicates the zero of the currents, and the dark lines are impulses of electricity. When these lines are above the zero they indicate positive impulses, when they are below, they indicate negative impulses of electricity. The vertical thickness of the electrical line from the zero indicates the intensity of the current at the point observed, so you will see that the characteristic of an intermittent current is the alternate presence or absence of electricity from the circuit. The characteristic of the pulsatory current is a pulsatory change in the intensity of the continuous current; but the undulatory current, to which your attention will be chiefly directed to-night, is a continuous current of electricity, the intensity of which varies gradually, and in a manner proportional to the varying velocity of a particle of air.

The three radical varieties of telephonic currents may be subdivided into direct and reversed currents, or those in which the impulses are all of one kind, either positive or negative, and those in which the impulses are reversed or are alternately positive and negative. You may still further discriminate varieties or direct currents accordingly as the impulses are all positive or negative. You may have a positive intermittent, or

* Obligingly supplied by the Society of Arts, where Mr. Bell gave it as a lecture.

a negative or reversed intermittent current, so that you have nine varieties of telephonic currents.

So far as I have been able to find, all previous experimenters in this branch of science have used intermittent or pulsatory currents in their attempts to produce sound, and I believe that I am the first to conceive of the employment of undulatory currents, whereby not only a noise or musical sound may be produced electrically, but sound of any kind—the *timbre* of the sound as well as the pitch and force of it being preserved.

The question will naturally arise in your minds, how can these currents of electricity be produced? It will be my object to-night chiefly to speak of the undulatory current, and the means of producing it; but I may here state that I have not yet been able to produce a true undulatory current, and the methods which I shall show you to-night are only approximately undulatory. I shall pause, then, first, to consider one of the means by which intermittent currents of electricity can be produced, and I will have thrown on the screen an illustration of an apparatus devised by Helmholtz, consisting of a tuning-fork placed between the poles of an electro-magnet; a platinum wire attached to one of the prongs of the tuning-fork dips into a cup of mercury, thus completing a voltaic circuit. So long as the platinum wire touches the mercury a current of electricity traverses the circuit, passes through the fork, and then through the electro-magnet, and so to the other pole of the battery. Under these circumstances, so long as the circuit is closed, the soft iron core of the electro-magnet attracts the prongs of the tuning-fork and the result is that the prongs are separated: the result of that is that the platinum wire is lifted out of the mercury; the moment it leaves the mercury the circuit is broken, the current of electricity ceases, the magnetism of the magnet ceases, the attraction of the iron core ceases and the fork springs back by its own elasticity. Hence, the moment the platinum wire touches the mercury again, the prongs are again attracted apart, and are again released, so that the result is that the fork is thrown into continuous vibration, and at every vibration it makes and breaks the voltaic circuit, thus causing an intermittent current of electricity.

The means by which a musical tone can be produced by means of this intermittent current of electricity will be shown in the next illustration, which is a fork, also arranged by Helmholtz, by which one tuning-fork is made to communicate its vibrations to another fork of the same pitch, by means of an electrical current conveyed through a wire. By the use of a resonator placed in front of the second fork, you can reinforce the sound and make it louder or softer, by opening or closing the orifice of the resonator. An arrangement by Helmholtz will next be shown, by means of which a number of tuning-forks are set in simultaneous vibration by the action of one fork dipping into mercury, so that you have a large number of musical tones produced simultaneously from these forks. Helmholtz made a very remarkable experiment with these forks, varying their loudness by resonators, so as to combine the musical tones in different proportions, and the result was that he was enabled to copy the *timbre* of sound. He was able to produce, by this external reinforcement of the forks, the effects of certain vowel sounds, for instance, *oo* or *ah*, different forks being reinforced in different degrees.

I shall now show you the diagram of an apparatus for the production of an approximately undulatory current of electricity. I have here a harp of steel rods attached to the poles of a powerful permanent magnet, and the same arrangement is repeated at the other end of the circuit. Between the rods of this harp we have at each end an electro-magnet. We know that when we move a magnet in the neighbourhood of an electro-magnet, we induce in the coils of the electro-magnet a current of electricity, the intensity of which is proportional to the velocity of the motion of the magnet; and not only so, but the kind of current, or its polarity, depends on the direction of the motion of the magnet. If I move my magnet downwards, I produce, say, positive electricity; and then, on the other hand, if I move it upwards, I produce negative electricity, so that it is evident to you that, when we vibrate a permanent magnet in front of an electro-magnet we produce a reversed current in the electro-magnet, and the intensity of the current is proportional to the velocity of the moving body. Hence, we have our undulatory current of electricity. This undulatory current may be utilised to produce a sound at the distant end of the current in the following way. Let us suppose, for instance, that we have these two harps, that we pluck with the finger one of these rods; it vibrates, and produces a certain musical tone. In vibrating, we have an undulatory current of electricity produced, which traverses the circuit and passes round the coil of the distant electro-magnet. What is the result there? The result is, that this electro-magnet alternately attracts and repels the rods about it, the positive current attracting, and the negative current repelling them; so that when an undulatory current traverses it we have a succession of positive and negative impulses, and the soft iron core alternately attracts and repels the rods above it, and the rod which is in unison with the one agitated at the other end will be thrown into vibration. So that, if you were to play a tune upon this harp, the corresponding rods at the other end would be thrown into vibration, and the tune would be reproduced. But you will observe that the vibration of this harp is not communicated through the wire mechanically; as in the case of the piano experiment that I have referred to; but the vibration of the rod creates or induces a current of electricity, which current traverses the wire—of course, with the speed of electricity—and will go to any distance, so that instead of having one of these pianos on each side of the road you may have them hundreds of miles apart, and a telegraph wire between them, and play one piano, and the other will appear to play by itself.

If I were to show you Helmholtz's apparatus for the artificial production of vowel sounds, you would see that certain *timbres* of sound were produced by causing the tuning-forks to sound simultaneously, with different relations of force. By the arrangement just described we can cause certain of the rods of the harp to vibrate with certain relations of force. For instance, if I pluck one of these rods very forcibly, the current of electricity produced will be very intense, because the intensity of the current depends on the velocity of the moving body. Hence, when you vary the amplitude of the vibration you vary the intensity of the current. Accordingly, if you pluck one of the rods very forcibly, you will have an intense current produced, and the corresponding rods will be thrown into vibration forcibly, but if you pluck the rod gently a feeble current will be produced, and the rod at the other end is thrown into vibration feebly. If you sound a number of those rods simultaneously, with different relations of force, you will find the rods of the corresponding harp thrown into vibration, with corresponding relations of force. So that if you can produce a vowel sound by vibrating simultaneously a number of these rods, you can transmit a current of electricity which will produce the same sound from the harp at the other end of the wire. If you sing into a piano, keeping the pedal down so as to leave the strings free to vibrate, you will find that not only is the pitch of your voice echoed back to you from the piano, but also an approximation to the quality of the vowel. If you sing *ah* or *oo* you will find an approximation to these sounds produced from the piano. And the theory shows that if the piano had a very much larger number of strings to the octave, we should have not an approximation but a *fac-simile* of the vowel sound. When you sing the sound into the piano, certain of the strings are set in vibration sympathetically by the voice, with different degrees of amplitude, and the result is that you have these strings going on vibrating after the voice has ceased, with the result that the force and the vowel sound is echoed back.

The next illustration shows you my first form of articulating telephone. If you had a large number of steel rods to the octave, and were to speak in the neighbourhood of such a harp, the rods would be thrown into vibration with different degrees of amplitude, producing currents of electricity, and would throw into vibration the rods at the other end with the same relative amplitude, and the *timbre* of the voice would be reproduced.

However, there are still simpler methods of producing undulatory currents of electricity, and the best way of showing you the method of producing the required current will be to trace the various steps by which the present telephone has grown from the apparatus I have just shown you.

You will observe the effect produced upon the line of wire by the vibration of two of the rods of the harp I have spoken of; and in the next illustration I show you the effect of vibrating a number of permanent magnets simultaneously over an electro-magnet.

[Professor Bell here described in detail, and showed by a diagram, the result of the combined vibrations of two notes forming a major chord, the ratios of the vibration being as 5 to 4, and the resultant curve being the algebraic sum of the two.]

The effect is, when you vibrate more than one of these rods simultaneously, to change the shape of the electrical undulation, and a similar effect is produced when a battery is included in circuit. In this case the battery current is thrown into waves by the action of the permanent magnets. Hence, you will see that the resultant effect on the current of a number of musical tones is to produce a vibration which corresponds in every degree to the moving velocity of the air. Suppose, for instance, you vibrate two rods in the harp, you have two musical notes produced; but of course if you pay attention to a particle of air, it is impossible that any particle of air can vibrate in two directions at the same time; it follows the resultant form of vibration. One curve would show the vibration of a particle of air for one musical tone, the next one for another, and the third the

resultant motion of a particle of air when both musical tones are sounded simultaneously. You have, by this apparatus, the resultant effect produced by a current of electricity, but the same resultant effect could be produced in the air. In order to show you the resultant vibration of the air from different sounds, I shall put another illustration on the screen. This shows, not the variation of intensity of a current of electricity, but the variation of the velocity of a moving particle of air ; and the curves now on the screen represent graphically the movements of air for certain vowel sounds. They have not been theoretically calculated, but are actually tracings produced by the voice itself. Of course, we all know the instrument entitled the phonautograph, and these curves were drawn by an improved form of phonautograph. There was a cone into which you spoke, which condensed the air from your voice ; at the small end of the cone, you had a stretched membrane, which vibrated when a sound was produced, and, in the course of its vibration, it controlled the movement of a long style of wood, about 1 ft. in length, and these curves were drawn by the style upon a surface of smoked glass, which was dragged rapidly along. I myself uttered the vowels that are here shown, viz., *e, ay, eh, ah, aah ;* these vowels were sung at the same pitch and with the same force, but you will observe that each is characterised by a shape of vibration of its own. In fact, when you come to examine the motion of a particle of air, there can be no doubt that every sound is characterised by a particular motion. It struck me that if instead of using that complicated harp, and vibrating a number of rods tuned to different pitches, and thus creating on the line of wire a resultant effect, we were at once to vibrate a piece of iron—to give to that piece of iron not the vibration of a musical tone, but to give it the resultant vibration of a vowel sound, we could have an undulatory current produced, directly, not indirectly, which would correspond to the motion of the air in the production of a sound. The difficulty was, however, how to vibrate a piece of iron in the way required. The following apparatus gave me the clue to the solution of the problem in the attempt to improve the phonautograph :—I attempted to construct one modelled as nearly as possible on the mechanism of the human ear, but upon going to a friend in Boston, Dr. Clarence J. Blake, an aurist, he suggested the novel idea of using the human ear itself as a phonautograph, and this apparatus we constructed together. It is a human ear. The interior mechanism is exposed, and to a part of it is attached a long style of hay. Upon moistening the membrane and the little bones with a mixture of glycerine and water, the mobility of the parts was restored, and on speaking into the external artificial ear, a vibration was observed, and after many experiments we were able to obtain tracings of the vibration on a sheet of smoked glass drawn rapidly along. Many of those were very beautiful, and I am sorry I have not any of them here to-night to show you, but as it is foreign to our subject, it is, perhaps, as well. I would merely direct your attention to the apparatus itself, as it gave me the clue to the present form of telephone. What I wanted was an apparatus that should be able to move a piece of iron, in the way that a particle of air is moved, by the voice. It struck me in the course of these experiments that there was great disproportion between the tissue of the membranes and the bones that were moved by the membranes, and that if such a thin and delicate membrane could vibrate a mass of bone, so disproportionate in size and weight, perhaps a membrane might be able to vibrate a piece of iron in the way required. I therefore constructed a second form of articulating telephone, founded on the first apparatus by which I was, at the time of these experiments, producing undulatory electricity for the purpose of producing musical tones. It was similar to the rods shown you before, except that instead of being attached to a permanent magnet it was attached to one pole of an electro-magnet, and magnetised by means of a battery current. A current being passed through the coils of the magnet this piece of iron became magnetic, and a rod attached to one pole would of course become magnetic also, as if attached to a permanent magnet, so that, on vibrating this rod in any way whatever, the battery current was put in operation and the corresponding rod at the other end thrown into vibration. I, therefore, took this apparatus, and instead of clamping the rod firmly, it was attached loosely to one extremity of the magnet, and the other end was attached to a stretched membrane of goldbeater's skin : and the same at the other end. The idea was that on speaking to this membrane, it would be thrown into vibration, and cause the vibration of the piece of iron, that in fact the iron would follow the motion of the membrane, that is, of the particles of air ; it would, therefore, induce an undulatory current of electricity the intensity of which would vary with the motion, and at the other end the intensity of the magnetic attraction would vary in a similar way ; so that the piece of iron at the other end, being attracted and repelled in a varying manner, would be thrown into vibration, copying the motion of the first, and it in turn would cause the motion of a second stretched membrane, which would move the air in the neighbourhood, and we should thus have a sound produced. The idea was, that not only would the two pieces of iron vibrate together, but the form of the vibration would be the same, so that on speaking in the neighbourhood of one membrane we should have a fac-simile of the sound produced, at the other end. The apparatus was constructed, but the results were rather unsatisfactory. My friend, Mr. Thomas Watson, who assisted me, however, asserted that he could hear a very faint sound proceed from the second membrane when I spoke in the neighbourhood of the first. Encouraged by this fact, I varied the apparatus in a number of ways, and eventually produced three distinct forms of apparatus, which were exhibited at the Centennial Exhibition. I came to the conclusion that this piece of iron was probably rather too heavy to be set in vibration by the membrane, and I therefore made it as light as possible ; in fact, I took a piece of steel spring, only about the size of the pole of the electro-magnet itself, and glued it to the centre of the membrane. Upon constructing two of these instruments, there was no mistake at all that articulate speech was produced ; but it was of a very imperfect nature. When a person spoke or sung into one of these instruments, you could distinctly here the tones of the speaker's voice at the other end, and could recognise that there was articulation there, and when you knew the sentence that was uttered, you could recognise the articulation, and it seemed strange that you could not understand what it was at first. The vowel sounds seemed to be copied very fairly, but the consonant sounds were entirely alike.

Another form of apparatus constructed at this time for producing an undulatory current, I have a photogaph of, but it is a different size to the others, and cannot be thrown on the screen. It consists of one portion of the apparatus turned horizontally ; attached to the membrane of gold-beater's skin is a little bit of cork carrying a platinum wire, which dips into a cup containing water. We know that water offers an enormous resistance to the passage of an electrical current. If you place two wires in water, separated by a slight distance, the resistance offered by the water is very great ; but if you bring the wires nearer together, the resistance becomes less and less, so that the current of electricity becomes stronger and stronger, and when the two wires can be put in actual contact the resistance of the water may be ignored altogether. Hence you can see that by vibrating two wires to and fro in a liquid of high resistance included in the circuit, the battery current can be thrown into waves, and the resulting current may be considered as approximately undulatory ; and with this form of apparatus I was able to produce articulate sounds. But it was no improvement on the first. I produce the effect of articulate speech by vibrating the conducting wire in this way in pure water, in water acidulated with dilute sulphuric and other acids, in salt and water, and in a number of other liquids. I also produced the same effect by vibrating a solid of high resistance in a liquid of low resistance. Instead of a platinum wire dipping into water, I had plumbago dipping into mercury. The plumbago offered a good deal of resistance to the passage of the current, but as it dipped into the mercury it offered less and less, and by having a very small piece of plumbago vibrating in the mercury, the current was varied in a manner approximately undulatory, and articulate effects were produced when this apparatus was used as a receiving instrument.

I found, however, that the best means I could devise for producing an undulatory current was the apparatus I will now show you, but it did not serve well as a receiving instrument, and I was therefore led, after many experiments, to construct another form of receiving instrument, keeping this for transmission.

This [a diagram of the instrument was thrown on the screen] is one of the forms shown in the Centennial Exhibition. On speaking into this, and listening to the other, articulate sounds were heard very distinctly.

The next illustration shows the form of receiving instrument to which I was led. It consists of a hollow box of iron, with the electro-magnet inside, and a thin diaphragm of iron laid on the top as a lid. Upon resting the ear closely against this diaphragm, articulate sounds were very clearly perceived, when the first instrument, as shown at Philadelphia, was used as a transmitting instrument. I was so convinced, from these experiments, that the inductive method of producing an undulatory current was the best method, that I determined to vary the construction of the first form of apparatus, and I gradually varied the size and power of my magnet, and the size and thickness of the iron spring attached to the membrane, and the size of the coil. I found, as I diminished the size of the coil, the resulting sound at the other end became very much louder ; in fact, I found there was no advantage in using a coil that extended beyond the centre of the magnet. Indeed, there is very little difference, in effect, between a coil of that size, and a

mere flat spiral placed once round the magnet. The important point is to cover the pole of the magnet. Every succeeding turn adds resistance, without increasing materially the loudness of sound. I varied the power and size of the magnet by varying the power and size of the voltaic battery employed to magnetise it, and found that very little effect was produced by diminishing the power of the battery. In fact, the effect of articulate speech was produced from the receiving instrument when the battery was entirely removed from the circuit. In that case the only source of power would be the residual magnetism of the iron bar, and that showed that the only use of the battery could be to magnetise the iron bar; so, in subsequent forms, I dispensed entirely with the voltaic battery, and used a straight bar of iron magnetised steel. Increasing the size of the iron plate attached to the membrane, a very large increase in the loudness of the sound resulted, until finally I had a plate of iron almost as large as the membrane itself. By this, dispensing with the membrane altogether, perfect articulation was, for the first time, obtained, and in this form, which differs very immaterially from the present form, you have a plate of iron vibrated by the voice, in front of a permanent magnet with a coil of wire around it.

On varying the size and thickness of the permanent magnet, it is found that wonderfully little difference is produced by magnets of very different force, and on varying the size, diameter, and thickness of the iron plate wonderfully little difference is produced. The chief difference is a peculiar effect on the quality of the voice. I have produced distinct articulations from iron plates all the way from 1 in. in diameter up to 2 ft., and from 1-64th in. to 3-8ths in. in thickness. In fact, if you take an ordinary Morse sounder, and use that as a receiving instrument, using a battery current to magnetise it, if you place the armature of the Morse sounder close against your ear, articulate sounds are produced from it. This shows very distinctly that the effect is probably molecular rather than anything else, and the vibration of the plate as a whole mars the effect. One of my best forms of instrument was constructed on this model, but I had the cavity completely filled with a pad, to prevent the vibration of the plate as a whole, and it articulated beautifully. When the pad was taken out, a peculiar effect accompanied the articulation—a drum-like effect, due probably to the vibration of the plate as a whole. In fact, I can describe very distinctly the effect produced by varying the size of the plate. Suppose we keep the plate of uniform thickness, and vary the diameter, commencing with a small plate, we have articulation perfectly distinct, but it sounds as if you were speaking with a cold in your head; a purely nasal quality accompanies the sound. Now, keep the thickness uniform, but enlarge the diameter, and as you do so the nasal effect wears away, until, with a certain diameter, you obtain a very good quality of voice. Keep on enlarging it, and a coarse, hollow, drum-like effect is produced, and when you have it very large it sounds as if you had your head inside a barrel—a kind of reverberating sound. So keeping the diameter of the plate uniform and varying the thickness, commencing with a very thin plate, you will have the same drum-like effect. Now, as you gradually thicken the plate, you have the effect disappearing. Then you get articulation, and as you go on increasing the thickness you have that peculiar nasal quality produced, so that it is probable that the fundamental pitch of the plate itself has a great deal to do with the agreeableness or disagreeableness of the electrical articulation, but the size or thickness does not seem to impair the distinctness of the articulation itself. You see there is a peculiar form of mouthpiece for concentrating the air on the plate. I made one experiment of rather a striking nature, viz., I omitted entirely the cavity in the mouthpiece. The iron plate was glued solidly at every point against a block of wood, and I talked against the surface of the block, so that there was an inch of wood between my mouth and the iron plate. Yet I was able to carry on a conversation with a man three miles away. I will now show you the last form of apparatus, and it differs very little from the previous one. [Professor Bell here explained in detail, by the aid of the illustrations, the form of instrument.]

The effect of reversing an undulatory current is to strengthen and weaken the magnet, and the result is that the plate is attracted in a varying manner, and the plate at the receiving end vibrates in a similar manner to the one at the transmitting end, and so a similar sound is produced. You, therefore, have the voice of the speaker converted into electricity here, and at the other end of the circuit you have the current of electricity reconverted into sound. No voltaic battery is used in this form—nothing but the magnet itself. I may here state one defect of this current. I have stated that I have not yet discovered the means of producing a strictly undulatory current. It frequently happens that, for practical purposes, the current is sufficiently undulatory to produce, at the other end, the effect of articulate speech, but the current produced in the coil is not strictly proportional to the velocity of the motion of the plate, as was pointed out to me by my friend Professor Cross, of the Institute of Technology at Boston, for there is another effect produced depending on the proximity of the iron plate to the pole of the magnet. If it be moved with a certain velocity, and the plate is very near the pole of the magnet, the effect produced would be very much greater than if it were farther away, so that you have the approximation of the separation of the two affecting the result. In fact when the plate vibrates towards the pole, the current produced is too strong, and when it goes from the pole of the magnet it is too weak so that the effect is not strictly an undulatory current. If the amplitude of the vibration of the plate is very great the defect is magnified, but if it is lessened the effect more nearly approximates to the undulatory character. Hence the curious effect, that soft speaking is much more distinct than loud speaking. If you shout or roar into the telephone, you have the sound produced at the other end very loudly; but a discriminating ear will recognise that the articulation is not so distinct as when you speak more softly into the instrument. However, theory shows one way in which the defect can be remedied. Suppose we have alternate impulses going along the wire, and that, when the plate comes towards the magnet, we have a positive current produced, and when it goes away, a negative current. The coil may be so arranged that, when the positive current traverses it, the magnet will be strengthened, and it will then attract the plate with greater force; and thus, when the first plate approaches the magnet, the other will do the same, and thus the defect will be magnified. But we may also arrange the coil so that, when the first plate approaches the magnet, the other will recede from it, and thus the effect I have spoken of will be neutralised.

This leads me to a very curious point in the use of the telephone, viz., that you can control the phase of a vibration by specially arranging the coil. You can take two telephones and arrange them so that, while some person makes a musical tone into the receiving instrument, the phases of vibration of the plates shall be identical or opposed. Sir William Thomson, a few days ago, made an experiment of this kind with me in Glasgow, and we found that the telephone is a beautiful instrument for illustrating the interference of sound. If you arrange the instruments so that you have the phase of vibration the same, and then place your ear to the instrument, you can perceive the sound approximately doubled in intensity; but arrange them so that the phases are opposite, and there is a "dead spot," —silence is produced at one point. I never heard interference of sound so beautifully illustrated as in that experiment, and there is no doubt that many uses can be made of the instrument in acoustics, from the fact of our being able to control precisely the relative phases of two vibrating bodies. The experiments made with this telephone a few days ago by Sir W. Thomson have demonstrated the fact of an interference in the perception of sound. For instance, take two instruments, one vibrating in a certain phase, and the other in a phase nearly, but not quite the same. Place one to one ear, you perceive the sound on that ear alone. Place the other to the other ear and you perceive it on that ear alone. Place them to both ears at once, and you can arrange the phases of vibration so as to make both tympanic membranes act at the same time, or vibrate in a different manner; and there is a curious difference in the perception of the sound. It cannot be described, but it is something of this kind. You place the instrument to each ear in that way; where the phases are identical, you have a single sound, and you may localise the sound say on the surface of the two ears, but when the phases of the vibrating plates are reversed, the locality of the perception seems to change, and it seems as if you heard the sound at the back of the head, instead of at the surface of the ear. Moreover, if you take two distinct circuits, and have one telephone on one circuit, and one on the other, and have a musical tone produced from one telephone, which is almost, but not quite, in unison with that produced from the other, you have beats.

We know that if two organ-pipes, for instance, were vibrating in this room, the pitches of which were adjusted in that way, we should be cognisant of beats, illustrating the interference of sounds of that sort. Sir William Thomson writes me that he has shown that the same effect is produced in the sensation of sound, for, placing one plate to one ear and the other plate to the other ear, so that each perceived only one sound, the same effect of beats was produced, showing very conclusively the interference in the sensation of sound itself.

The next illustration shows the way in which the telephone can be employed for the actual purpose of conversing at a distance. It is preferable to employ for this purpose two telephones, one in front of the mouth, and the other at the ear, for it has been found that when one telephone alone is employed, it

constantly happens that persons separated by miles of distance speak at the same time or listen at the same time, and by placing one telephone to the ear and the other to the mouth, conversation at once becomes practicable.

Of course the question will naturally arise how far can it be possible to use the instruments? That as yet we do not know. The limit has not been found. In laboratory experiments no difficulty has been found in using an apparatus of this construction through a circuit equivalent to 6,000 miles. In this instrument we have a powerful compound permanent magnet. The longest actual wire I have been able to experiment upon has been 258 miles in length, and no difficulty was experienced so long as the other parallel wires were not in operation. The instrument is wonderfully sensitive to inductive influences, and when you use a wire upon the poles with other wires you have the benefit of the other messages that are passing along the other wires on the telephone. However, means have been discovered very recently by which the inductive influence of other wires can be overcome and neutralised, so that I hope we may have the instrument in use upon circuits of all lengths. I do not know that there are any other points that I should like to mention to you to-night, excepting a new application that is shown here to a diving apparatus. Inside the diver's helmet you place a telephone of convenient structure, and in the place of using a separate telegraph wire, we use the wire that is coiled up inside the breathing pipe. In every breathing pipe of course there must be a coil of wire, in order to withstand the pressure of the water, and that wire we find can be used for the purposes of the telephone, so that the wire inside this pipe is connected with the telephone inside the diver's helmet, and the earth connection is simply made by attaching the other wire to the helmet itself which is in contact, outside, with the salt water. I had the pleasure of trying to converse with a diver yesterday, with perfect success, at Messrs. Siebe and Gorman's, in a tank. He heard every word I said, and I was able to understand every word he said; and when I told him to come up, by word of mouth, he obeyed me. I do not know that there are any other points of interest to you, but I shall be very happy to attempt to answer any questions that may be put.

Mr. S. Ford asked what was the difference between this form of telephone and that shown at the Queen's Theatre some time ago by Mr. Varley; also whether the time was increased before the sound was received according to the length of the wire.

Professor A. G. Bell said the telephone of Mr. Varley was similar to his only in name. There was no similarity whatever between the ingenious apparatus devised by that gentleman for producing musical tones, by the action of intermittent currents of electricity and pulsatory currents, and his own apparatus for producing the *timbre* of a sound by utilising undulatory currents of electricity. There had been numbers of telephones brought before the notice of the public, but all previous telephones had consisted merely of methods for producing musical tones, and he believed his was the first which had been constructed in which the *timbre* of the sound was copied. In reference to the other point, he might state that no difference had been observed in the time required for transmitting sound. In conversing with his friend, Mr. Watson, when he was in New York and the latter in Boston, he put questions to him through the telephone, and instantly the answer came back as though they were in the same room, instead of being separated by 258 miles of actual distance. The speed was the speed of electricity, not the speed of mechanical vibration.

Mr. J. Scott Russell, F.R.S., said he did not rise to put any questions, but to express what he felt sure was the feeling of many present, of extreme gratitude to the lecturer. There was probably no one who felt that debt more deeply than he did. The paper had taught some doctrines wonderfully wider and grander than even the interesting doctrines of the telephone, and taught them that the electric wave which went through the conducting wire was a wave, as was well said, not of mechanical force, but a wave of ethereal force, meaning the impalpable atmosphere through which the waves or electric force were transmitted at present by electric cables from England to America, and this same electric, atomic, or ethereal force was propagated at a uniform velocity, whatever was its nature, through a given wire or channel. But if, instead of this electric wire, he were to take a great channel of water 100 miles long, and then to take, instead of the plate of iron, or drum, a large plate of iron moved by a mechanical force—much like that which moved the drum of the ear—the force which he put into one end of the water channel would carry to the end of the 100 miles an exact copy and measure of the force which he had put into it at this end. This existed in air, in water, in electricity, and in ether, and it was one and the same law which governed all. The same propagation through the same ether brought the rays of the sun's light from the sun to the earth, and the same carrier wave brought from the other side of the globe, from the oceans there, which were disturbed by the attraction of the sun and moon, those waves all round the coasts which were called tides. All these phenomena, from the tides and the wind to the rays of light and to the sounds of the telephone, were the motion of one simple phenomenon, the carrier wave, the wave of translation. In conclusion, he begged to move a hearty vote of thanks to Professor Bell, which was carried unaminously.

But something more must be known by experiment at least before this is acceptable as a practical matter.

TELEGRAPHY.

FOUR messages on one wire has been spoken of in recent numbers of our journal as a fact. In our notice of Sir Charles Wheatstone the history of telegraphy is already described. The "needle" began the story and the "double needle" followed suit. That became the commercial implement of communication, and is the best where extraordinary political or other speeches have to be sent in. Commerce is satisfied with the double needle where no great length is demanded, and it is the best for signalling, which is no slight compliment. We had subsequently a printing and perforating process that is not worth remark except that it was ingenious. Then followed Wheatstone's method and Morse's also. After them the Hughes Type Printing Apparatus which enables the printers to "set up" from the printed slip of paper without previous transcription or preparation of any kind. The Hughes instrument differs from all others in that it is mainly mechanical, the electrical action being confined to the sending a single short current at the instant the type-wheel is in the proper position; and only a single wave is needed to produce a letter. The sending and receiving instruments are exactly alike, and are manipulated by means of a keyboard somewhat resembling that of a pianoforte, of as many keys as there are letters, figures, and signs to be printed. For every depression of the piano-like key of the Hughes instrument a letter is jerked out at the distant end, while under certain conditions combinations of as many as five letters can be produced during a single revolution of the type-wheel. Perhaps no greater contrast to the Double Needle telegraph, which required numerous combinations for almost every letter, and often a second operator to write the messages down, could be found than the nimble though noisy "Hughes," the use of which is now almost solely confined to the Continental systems. The "Bell" telegraph of Sir Charles Bright, worked almost exclusively by the late Magnetic Telegraph Company, has probably never been excelled for speed by any acoustic system of telegraphy; in addition to which it may be worked interchangeably with the Single Needle telegraphy, now so commonly used at the smaller post offices, and on railways. Curiously enough, however, it has almost dropped out of use. Among the minor inventions which have contributed in no small degree to the success of practical telegraphy in England, must be mentioned those of Mr. Cromwell F. Varley, at one time electrician to the late Electric and International Telegraph Company. At this moment the Varley Insulator is probably the most perfect form of insulator in use.

In dealing with the next phase of telegraphic progress we are carried back to first principles, so to speak. Just as Sir Charles Wheatstone was practically the first inventor in the English telegraphic field, so he may be said to have been the latest; the Automatic telegraph, which bears his name, being probably the latest English invention which has been adopted into our postal system.

The Wheatstone method is capable of producing and recording no fewer than 120 words or 600 letters per minute; and inasmuch as the former required two wires, and the latter only requires one, the carrying power of the telegraph may be said to have increased sixfold between the earliest and latest inventions of the great founder of the automatic system. It is doubtful whether, but for this invaluable method of transmission, the Post Office could have coped efficiently with the great service of news distribution which its increased facilities have practically created. For it has to be borne in mind that not only in the matter of speed, but in the adaptability of the preparatory process to a large number of transmitting machines, the automatic system is perfectly unique, and is as yet unsurpassed as a "single" system. Necessarily complex and delicate in its arrangements, the automatic telegraph is a curious contrast to that other invention of Wheatstone's, the Alphabetical, or "A, B, C" tele-

graph, which, as its name implies, is the very alphabet of practical telegraphy. Next to the automatic, in point of time, comes the "Duplex," or double-working system.

Out of the Duplex sprang the Quadruplex system, the latest, as it is the most lively, instance of telegraphic progress. Very little appears to be known about the system as yet, except that it comes to us from America, where it is said to have been adopted with the most perfect success on the great telegraph lines. It is the invention, so far as we can make out, of Messrs. Prescott and Gerritt Smith, electricians to the Western Union Telegraph Company of New York, and may be briefly and popularly described as the Duplex doubled. The clerks work in pairs at either end of the wire, through which a double stream of messages is sent in both directions simultaneously, and the method of receiving signals affords a striking exemplification of that which has made American telegraphy notable among the systems of the world—sound-reading. It has been frequently stated that the average speed of the ordinary Morse telegraph is from 30 to 40 words a minute, and we assume, therefore, that the speed of the Quadruplex method is about four times as great, or something more than the speed of the Automatic system worked singly as it now is. We are not aware of any attempt having been made to "double" or duplex this system; but we apprehend that there need be no difficulty in carrying out such a plan, and this being so, an improvement on the Quadruplex method would necessarily at once ensue. It is very desirable in the interests of the telegraph service, as well as those of the public, that too much stress should not be laid on these undoubtedly important improvements in the methods of telegraphic communication. High-speed systems of telegraphy necessarily involve high skill on the part of the operators, a high state of perfection in the lines, and a steadiness of climate which unfortunately does not belong to this England of ours. It is always well to remember what we pointed out in connection with the telephone, that what is possible in America, with its fine dry climate and long lengths of single telegraph line, is not always or even mostly possible in England, where the weather is "variable as the shade," and the wires on most trunk lines are as thick and close as the yarns of a rope-walk. If the Quadruplex Telegraph does nothing more than enable us to keep down the increase of wires on these already over-weighted routes, it will not have come in vain; although we should prefer to see an attempt made to exhaust the possibilities of our own Wheatstone system, before adopting a method which may, after all, only prove partially successful in our fickle climate. The Wheatstone probably stands alone among the fast speed methods in its freedom from interruption from atmospheric causes, and being automatic it does not, of course, necessitate the employment of highly-skilled operators.

THE GOVERNANCE OF OUR RAILWAYS.

BLOCK and Inter-lock are the distinctive characteristics of the public protection against accident and loss. There is no safety unless there is provision that shall give space, and Messrs Saxby and Farmer have for many years devoted all their skill, energy, and machinery to that end; and they have done their part right well. England and other lands owe them obligations of no common order; they have made safe what was unsafe: they have invented communications which, as by electricity, signify on our English railways the point of danger and the point of safety. This is effected by electricity giving the signals. A signal-man governs his brother signal-man by appliances that ensure perfect safety, if both mind, or attend to, their business. If the engine-driver is undutiful, the signal-man is spoiled; but if he is right, and the signal-man is true, no harm can come.

Interlocking appertains to the points and the out-of-door signals, and secures the safety of public traffic by transferring the carriages from one line to the other without risk. The line is made clear and the way indicated by signal, and the signal-man cannot alter the points. Signals and points are at one.

Thus we have two systems—the block and interlock—as perfect as human skill can make them, and when properly worked they are practically safe.

Mechanical powers depend on the exercise of human skill, and that is often faulty. These systems are of different origin and purpose. The signal-man can indicate a clear line below and would permit an incoming train to proceed; but he may turn the train on to the rails of an up-train, and deal destruction round the land. That we saw in the case of the Great Northern at Airsley last year, when a shunted train came into collision with an oncoming one.

This fearful case led Mr. Hodgson of Messrs Saxby and Farmer's establishment to join the two systems, and thereby destroy the chance of future danger.

The apparatus consists of a frame, containing in its lower portion the usual levers for working the points and outdoor signals, and in its upper a series of train telegraph instruments for signalling and recording. From each of these instruments a rod or spindle passes down to a series of sliding bars which are slid at right angles to revolving spindles, moved by the point and signal levers. The bars are provided with stops or projections, which are engaged with or disengaged from the mechanism of the levers as may be required. These operations are performed by hand by means of a small handle or lever on the top of the telegraph instrument. At the same time contact is either made or broken in the telegraph line wire, and by this means the indications "Line blocked" or "Line clear" are sent either up or down the line as circumstances require. We thus have a mechanical combination of the interlocking and block systems, in which both systems are operating at the same time and are made to work coincidently. The invention thus carries the security of the interlocking system a step further, the levers of the points and signals and the handles of the telegraph instruments being interlocked reciprocally, with the result that there cannot be any contradictory working between the outdoor signals and points, nor between them and the train telegraph signals transmitted electrically.

The main signals, which are made visible on the telegraph instruments to each operator, are "Line clear" and "Line blocked." Now, before one signalman can telegraph back to another who has telegraphed to him that a train is coming, that the line is clear for it, the points and out-door signals must be in the proper position for that train to pass. Until they are so, the telegraphic instrument is locked, and the signal "Line clear" cannot be made. Similarly, when "Line clear" has been telegraphed, the points cannot be moved nor the signals altered for shunting to go on upon the clear road, until "Line blocked" has been telegraphed to the station on either or both sides of the signalman. The operation of sending the "Line blocked" message—and this alone—frees the levers by which the points and signals required for shunting can be operated. Again, assuming a train to be standing in a station, and ready to proceed on its way, the signalman cannot give the driver the outdoor signal for the train to start until he has signalled "Train on line" to the station in advance. The sending of this telegraphic signal alone releases the lever and enables it to be worked to give the starting signal, so that a train cannot go on its way unannounced unless the driver proceeds in utter disregard of the signal against him. But this is not all; the signalman cannot give the driver the outdoor starting signal until the men at the station in advance has telegraphed back "Line clear" in reply to the signal, "Train on line." In sending the "Line clear" message the man at the station in advance electrically unlocks the telegraph instrument, and through this the starting signal at the station from which the train is about to start, and so the train cannot proceed—except in defiance of signals—without the permission of the man at the station in advance of it. Thus permission for a train to enter a block section cannot be given without the consent and concurrent action of the signalman at both ends of that section. Nor is the train less protected at the rear than in front, inasmuch as until the signalman who has just started a train puts his starting lever, and consequently the starting signal, back to "danger," he cannot telegraph "Line clear" for the next train to the station below him, for his telegraph instrument remains mechanically locked. Further, when the starting signal has been put back to "danger," it cannot be given again without the consent of the man at the station in advance.

This secures the public against any misery from the carelessness of the signalman. He cannot send on a train, and he is forced to stop an opposing train; and therefore collisions are rendered impossible.

Colonel Yolland has given to the Board of Trade a report that this has his approbation, and the public owe to Mr. J. P. Knight, who is the general manager of the London and South Coast line, the expression of its respect and gratitude for a manifest augmentation of public security. The shareholders also must feel that such efforts of Practical Mechanics conduce to the augmentation of their valuable property.

It is clearly impossible to speak in terms of sufficient praise when any observation on the conduct of our railways is under discussion. Underdown, Knight, Allport, and those of all our main lines must have a responsibility we cannot describe; but they meet that great hazard with the courage of Englishmen.

Chemistry applied to the Arts, Manufactures, etc.

ABSTRACTS FROM FOREIGN PERIODICALS, TRANSACTIONS OF SOCIETIES, ETC.

Ventilation of Sewers in Towns.—Air in sewers could be kept in continual motion in one direction, so that no stagnation could take place, the danger attending the development of sewer gases would be avoided. Vertical shafts have been tried without success, they do not produce an upward current of the sewer gas or air. Similar shafts are now proposed by Mr. R. Parker, surveyor to the Board of Works for the Poplar district, but in place of using them as up-takes he provides their upper ends with a cowl, the opening of which is always presented to the wind which enters the sewers and keeps up a current that constantly changes the gaseous contents of the sewer by driving them out at every opening. Mr. Parker proposes to use "a number of cast iron shafts erected about 12ft. high and 10in. diameter, in convenient and open places, and also pipes of various sizes according to circumstances, from the sewers and existing drains at the rear of houses, to the house top as high as the chimney stack, and these pipes or ventilating shafts should be surmounted by a cowl, guided by a vane attached to it, so that its opening or aperture shall always be facing the wind. The air or wind impinging upon it will force down the air within it, and pass into the sewer and travel along it, entering all drains and ramifications to find an outlet so that it may escape. The air within the sewer requires very little force to cause it to move forward, as it has in itself a tendency to move upwards." He has made experiments described in a recent report to the Poplar Board, "to see if the force of the wind and air could be conducted into the sewers, in this way to force out the gases and keep up a constant current of fresh air; it has been found that there was always a downward current in the ventilating shaft, and an upward rush of pure air in all the gulleys and drains in its immediate neighbourhood." A shaft was constructed from a drain to the roof of a house in Bow, the distance from the cowl to the sewer being 13 ft. The average results of the first seven experiments gave:—Temperature outside-sewer, 43·28 deg.; temperature inside sewer, 48·86 deg.; velocity of wind outside sewer, 4·61 miles per hour; velocity of wind at junction of 9in. drain in sewer, 1·81 miles per hour. Cubic feet of air forced into sewer per hour, 42.10.

Bronzing of Iron.—Iron articles to be bronzed are, according to a process by Mr. P. Hess, heated in the air after being coated with linseed oil. Objects which cannot be exposed to high temperature may be steeped in a slightly acid solution of ferric chloride, plunged in hot water, and when dry rubbed with linseed oil or with wax. To preserve iron from rust the author recommends sulphide of copper. He steeps the iron for a few minutes in a solution of sulphate of copper, and then transfers it into a solution of hyposulphite of soda acidulated with hydrochloric acid. The result is a blue black coating, not affected by air or water.

New Metals.—Dr. J. A. Gruth of the American Philosophical Society announces the discovery of two new metals. Magnolite, a product of the oxidations of Coloradoite (telluride of mercury). It occurs very rarely with native mercury in the upper decomposed portion of the Keystone Mine, Boulder County, Colorado, associated with quartz, limestone and psilomelane. It crystallises in fine needles, colour white, lustre silky. Ready soluble in very dilute nitric acid and in hydrochloric acid. Composition, mercurous tellurate. ($Hg_2 TeO_4$.) Ferrotellurite occurs at Keystone mine, as above, associated with native tellurium, tellurite and a peculiar iron sulphide, in which a part of the iron is replaced by tellurium. Composition, probably, ferrous tellurate ($Fe TeO_4$.) It forms a crystalline coating on quartz, resembling delicate radiating tufts, or when in cavities, very minute prismatic crystals, between straw and cream yellow, or inclining to greenish. Insoluble in ammonia, soluble in hydrochloric acid.

Lactoscope.—Dr. Heusner, of Barmen, has recently devised a simple apparatus called a *lactoscope*, which is based on the opacity of pure milk. It consists of two round plates of glass about the size of a watch crystal, placed parallel and held about an eighth of a inch apart by a metal strip, which passes between them, dividing the space between them into two sections. In the lower section is placed and secured same pure milk, or, some permanent white fluid of precisely the same opacity as pure milk. On one of the glass plates are some fine black lines. The upper section is filled with the milk to be tested, secured by an elastic band. On holding the apparatus between the eye and the light, the black lines being on the side opposite the eye, the black lines are more distinct through the less opaque medium. If the milk is less opaque than the normal liquid, as shown by the lines being more distinctly visible, it has probably been watered or skimmed.

In regard to chemical analysis which is the only reliable test of milk, Professor Lehmann, of Munich, proposes, to save time, that a weighed quantity, say nine or ten grammes of milk, is diluted with an equal weight of water, and poured out in a thin layer upon a porous plate of burnt clay, very dense and fine-grained. The water as well as the milk, sugar, albumen, and a portion of the salts dissolved in it, are absorbed by the clay plate, while the total amount of fats and casein in the milk remain on the plate in the form of a thin skin or film, easily removed with a horn spatual, and then dried and weighed. To determine the fats this film may be extracted with ether, and the two most important constituents of milk quickly determined. It is sufficient to know the total weight of the principal solid constituents of the milk, and the amount of water, for which scarcely two hours are required. By this method a great number of samples can be tested at once without much trouble, without the use of numerous costly plantinum dishes and water baths. The operation is simple; it can be used by any person who possesses accurate balance weights and scales.

Columbium.—The *Manufacturer and Builder* notifies that "we shall soon hear of columbium-plating, a nickel which is very much whiter and like tin." We have had occasion to note something of the kind before now, and have no doubt that by some means the result will be a brighter manufacture than nickel; only we must watch to ascertain whether that brightness will continue before coming to a favourable conclusion. Columbium, it is said by our contemporary, "was first found more than fifty years ago in the United States, near Middletown, Connecticut, and named in honour of America." This confirms our suspicion, but he goes on to say, "It has been hitherto very scarce, but now has been found at Marion, N.C., and also in the Amazon stone of Colorado. *If it becomes abundant enough* to be used in the arts, we may soon have a valuable addition to the useful metals and also to their compounds and salts. The metal forms an acid like tin, called Columbic-acid; tin forms Stannic acid, and the compounds of this acid with bases are Stannates, very useful in the arts; the compounds of Columbic acid with bases must be called Columbates. They have not yet been investigated." We must wait for that investigation and then determine the practical worth of the new metal.

Use of Lime Water in Connection with Steam Boilers.—M. Hetet, in a letter to the *Comptes Rendus* Hebdomodaires des Séances, says that oil, when introduced into steam for the lucubration of the cylinders, &c., becomes decomposed into fatty acids and glycerine, which, when carried along to the condenser, reach the boilers where they accumulate and cause the water of the boilers to become an emulsion of fatty acids very speedily. These acids soon attack the boiler-plates, and form thick black deposits, mixtures of iron soaps, and oxide of iron in various proportions; and there adhere to the surface of metal, forming dangerous incrustations. He advises that the feed-water should be treated with lime water before it enters the boiler so as to render it neutral or slightly alkaline.

Imitation Terra Cotta.—*The Magazin Pittoresque* gives an original recipe by which it is stated plaster casts may be made to imitate terra cotta very efficiently. The colours necessary are, brick red, lamp black, zinc white, and yellow ochre, all in powder. The object to be treated is first carefully rubbed over with oo sand paper so as to remove all roughness of the surface or ridges indicating where the parts of the mould have been joined. The mixed colour consists of two parts yellow ochre, two parts brick red, and one part black. These are well rubbed together. Then three parts of zinc white are separately mixed with a little milk into a paste. All the ingredients are then combined in a mortar with eight or ten parts of milk, and the resulting mixture is passed through a fine sieve to remove any particles of the white. A soft brush is then used to spread the satin over the object, care being taken to lay it on evenly. After twenty-four hours a second coating is applied, and when the article is completely dry the brush marks can be rubbed out by the fingers.

Banana Cultivation at Panama.—There has been a largely increased cultivation of the banana during the past two years. An enterprising German has cleared and planted a large tract of land bordering on the railway about a mile from Colon, with this fruit. The wet rich alluvial soil of the isthmus is peculiarly adapted to the production, both in quantity and quality, of the banana. From this property as much as twelve hundred trees are exported monthly from Colon to New York, where they sell readily at an enormous profit. More than two hundred persons, chiefly Jamaicans, are employed on this estate.

Mechanical Fan.—A novel instrument for producing a refreshing current of air in a room, capable of being used in a lady's hand, in lieu of the usual fan, has been devised by General Franzini. By means of clock-work in the handle, set in motion or stopped at will, by pressing a button, an oval plate is caused to revolve; on its longer axis is an oval frame, in shape and size like that of the hand looking-glasses commonly in use. The revolving plate may be either a plain metallic sheet or a piece of plate looking-glass, and the frame is susceptible of any amount of ornament. The lady is thus saved the exertion of waving the fan in her hand. A similar instrument of a larger kind may be placed on a table, concealed, if desired, by a bouquet of flowers.

Double Staining Tissues with Indigo-Carmine and Carmine, is the title of a contribution to the *American Journal of Science* by F. Merbel. The recipe is:—The dye consists of two fluids made separately, but mixed before use. One, a boracic solution of carmine (carmine, ½ drachm, borax, 2 drachms, distilled water, 4 oz.). The other, a similar solution of indigo-carmine, (indigo-carmine, 2 drachms, borax, 2 drachms, distilled water 4 oz.). Indigo-carmine is the trade name for sulphindigotate of potassium, and is the same dye used by Chrzonszczewsky, in his researches upon the commencement of the portal duct. The specimens to be stained, if hardened in chromic acid, must be deprived of it by washing, and then be immersed in the mixed dyes for a quarter of an hour. After that they must be transferred to a saturated solution of oxalic acid, both to "set" the blue colour, as well as to lighten the general tint, and then, after having been washed in distilled water, mounted in Canada balsam in the usual way. The system is not perfected, a substitute for oxalic being a desideratum. That will be found.

Recording Telephones.—The world has scarcely been startled by the introduction of the telephone when a new surprise is announced. We learn from the United States that Mr. Eddison, a gentleman well known for his scientific attainments, has devised a means by which the utterances of the telephone may be put on record, and it will thus become possible to reproduce years hence, not only the words but the very inflection and tone of voice of individuals long dead. This is surely the most remarkable thing yet performed by electrical science. The method by which this result is to be produced is extremely simple. A speaking tube fitted at one end with a mouthpiece has at the other a metallic diaphragm—that is to say, a miniature drum head—which vibrates powerfully under the influence of the human voice. Attached to the centre of the diaphragm is a point, which acts against a small strip of paper drawn slowly under it by clockwork, as in the well-known Morse recorder. When the apparatus is in action, if any one speaks through the mouthpiece the strip of paper will be indented by the fine point. A somewhat similar instrument in which a point is fitted to an exceedingly delicate diaphragm is attached to a telephone. If now the prepared paper be drawn under this second point it will cause the diaphragm to vibrate precisely as though it were spoken to, and the result is that the telephone is put into action, and the sound of the original voice reproduced as often as may be desired, so long as the paper lasts. Think what use might be made of such an instrument in treasuring up the accents of a great orator, such as Mr. Gladstone or the Rev. Henry Ward Beecher. The notes of a *prima donna* can be put on record, and it may yet be possible to compare the voice of Patti with that of a songstress now unborn. It is confidently asserted that Mr. Eddison has already achieved such success that he fails only in recording the finer inflections of the voice. A few weeks since the world would have pronounced the whole idea of such an invention as fit only for the brain of a writer of fairy tales, but after the telephone all things appear possible in telegraphy.

Mortar.—Mr. Cox, of Rotherham, communicates a note on this essential ingredient in building, as to how and when it is best to use it. Lime is never found in the earth as pure lime, but always in union with other metals or gases. Carbonate of lime is semi-crystalline, close-grained, cold to the touch, but if submitted to the action of fire for twenty or thirty hours it becomes crystalline, porous, and warm. The reason is, the fire has driven off the carbonic gas, and it has become pure lime fit for the builder. When water is thrown on lime while it is fresh from the kiln, it will unite with the lime in certain proportions, and form a hydrate of lime, and the latent heat of water being set at liberty causes the great heat of new-slaked lime. Another result of putting water on lime is that the particles of lime lose all power of cohesion and become fine powder. No sooner has the heat evaporated from a newly-staked heap of lime than it begins to absorb carbonic acid gas from the atmosphere, and is quickly reconverted into a carbonate of lime; in this state it is said to be dead. I find mortar easier to use, and of cleaner work, if it lies two or three days after being made up before using it, but I do not think waiting tends to make it set better. Clean sharp sand mixed with lime makes it set harder than without it. Good mortar can not be made with soft or earthy sand, and in no case should the proportion exceed 3 to 1. Really good mortar ought to have 2 of lime to 1 of clean sharp sand. Water must always be perfectly clean, and then with lime fresh from the kiln 2 of lime to 1 of sand will yield a mortar that will set harder and stand the weather longer than the stone or brick it builds together.

Cement for connecting Metal and Glass.—A cement particularly adapted for attaching the brass work to bottle necks, lamps, &c., is made by boiling three parts resin with one part of caustic soda and five of water. The composition is then mixed with half its weight of plaster of Paris. It sets firmly in half to three-quarters of an hour. It is said to be of great adhesive power, not permeable by petroleum, a low conductor of heat, and but superficially attacked by hot water. Zinc white, white lead, or precipitated chalk may be substituted for plaster, but hardens more slowly.

Electro-Silicic Light.—M. Plante has called attention in the French Academy to the bright light obtained when an electrode of one of his secondary batteries (a powerful one) is applied to a glass tube or wall of a glass vessel containing a saline solution. With the positive pole a stronger force is required; but the light is more silent than with the negative, which produces some crackling. When the light appears an abundant white vapour is given off, having, according to the *Telegraphic Journal*, a slight alkaline reaction. The glass is strongly attacked and devitrified. It might be thought that the brightness was due to lime combined in the silicon; but in the spectrum there are no appreciable lines, except some traces of that of sodium; whereas a piece of lime spar, under the same conditions, gives distinctly the lines of calcium along with a continuous spectrum. The lines of silicium do not appear, being weak, and the spectrum being intensely luminous, just as the carbon lines are not perceptible in the spectrum from the voltaic arc. The silicic origin of the light is further proved by the fact that it is obtained likewise on contact of the electrode with pure silicon in the state of crystal of hyaline quartz. M. Plante purposes to distinguish this kind of light as the electro-silicic light.

Ebbw Vale Iron for Rails.—It stated that the Ebbw Vale Iron Company have obtained an order for about 6000 tons of iron rails for the Indian Government. These rails have to be made to a very strict specification, and the engineers who have ordered them assert that iron rails thus made are, for all ordinary purposes, quite as good as steel rails, while they cost £1 per ton less money. This would go far to confirm the old opinion that a properly made iron rail was not after all quite so inferior to a steel rail as some persons imagined. There can be no question but that in places where the traffic is very severe, steel rails should be used, but it is not quite certain that steel is worth £1 a ton more than iron rails, on lines where the traffic is moderate and the engines light. These conditions apparently prevail in the districts for which the Indian Government require rails.